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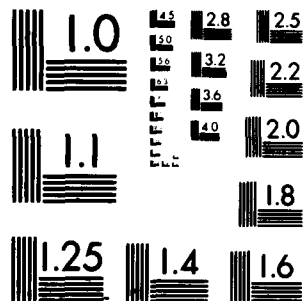
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CONSTRUCTION OF EXPERIMENTAL ROOFING.(U)
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TECHNICAL REPORT M-298
November 1981

CONSTRUCTION OF EXPERIMENTAL ROOFING

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by
Myer J. Rosenfield
Donald E. Brotherson

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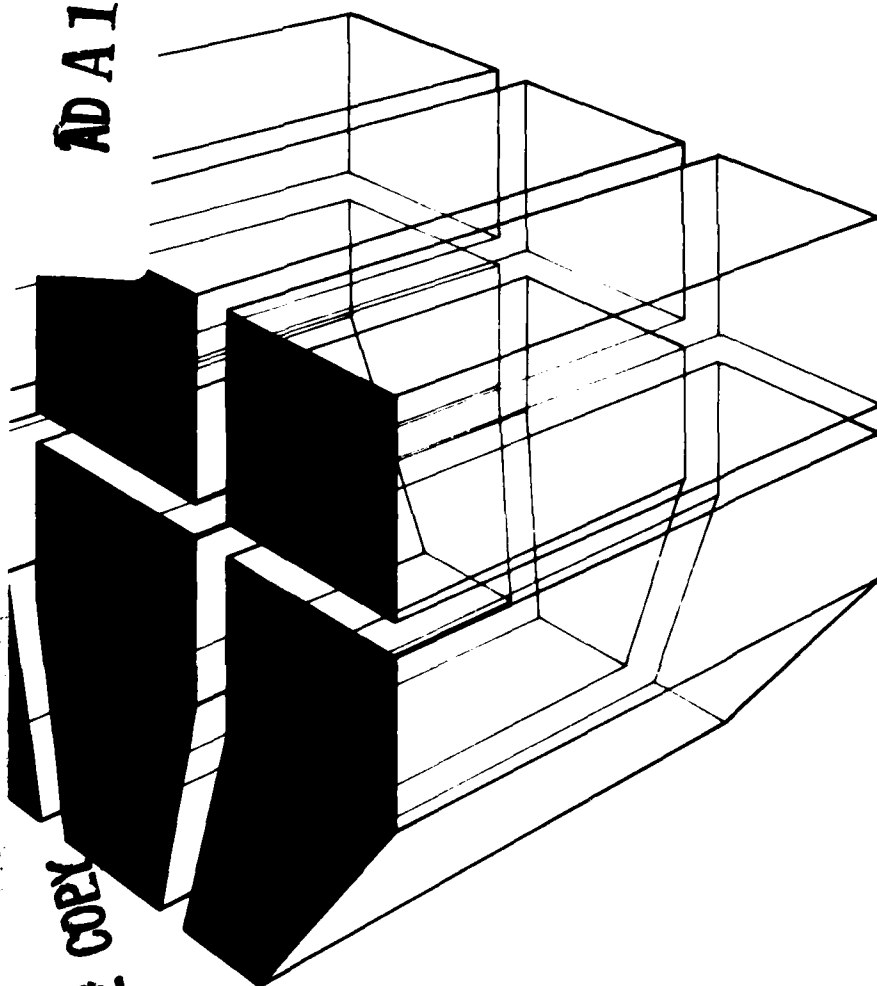


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➤ Sprayed PUF roofs coated with sprayed elastomeric material were installed on buildings at Fort Benning, GA; Fort Knox, KY; and Fort Lewis, WA. Sheets of EPDM synthetic rubber were installed on buildings at Forts Benning and Lewis. Built-up roofing systems were installed on buildings at Forts Benning and Lewis (for control purposes).

Thermocouples were installed below the insulation on all roofs, and thermocouples and strain gauges were installed above the membrane on the EPDM roofs at Forts Benning and Lewis, so that a continuous record could be obtained of heat flows and membrane movement. Samples will be taken from all roofs every 6 months for 2 years for laboratory testing, and the roofs will be visually inspected every year for 10 years. Weather recording stations were installed at Forts Benning and Lewis so that roof temperatures and movements could be coordinated with ambient conditions.

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FOREWORD

This research was conducted for the Office of Military Programs, Office of the Chief of Engineers (OCE) under Project 4A762731AT41, "Military Facilities Engineering Technology"; Task B, "Planning and Design"; Work Unit 002, "Improved Roofing Materials and Systems." The OCE Technical Monitors were Mr. J. Ichter, DAEN-MPE-S and Mr. R. Russo, DAEN-MPO-B.

The work was performed by the Engineering and Materials Division (EM) of the U.S. Army Construction Engineering Research Laboratory (CERL). Dr. R. Quattrone is Chief of CERL-EM.

Appreciation is expressed to personnel in the Directorates of Facilities Engineering at Forts Benning, Knox, and Lewis for their cooperation in contracting for the work and administering the contracts. Messrs. John T. Blair, Alvin Smith, Jack E. Davis, Paul Gill, Martin Savoie, James Gambill, and William Gordon made important contributions in monitoring and photographing the roof construction and installing the instrumentation systems.

COL Louis J. Circeo is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

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CONSTRUCTION OF EXPERIMENTAL ROOFING

1 INTRODUCTION

Background

Most Army facilities use conventional roofing systems, such as built-up roofing (BUR), that are sometimes expensive and complicated to construct. These conventional roofing systems are often also comparatively short-lived, resulting in high life-cycle roofing costs which are difficult for already overburdened Army operation and maintenance budgets to absorb. Therefore, the Directorate of Military Programs has asked the U.S. Army Construction Engineering Research Laboratory (CERL) to attempt to identify alternative, easy-to-install roofing systems that can improve the performance of Army roofing while reducing life-cycle costs.

Previous work identified and evaluated alternative roofing systems that would be less susceptible to installation error or misapplication and would not be as sensitive to storage, handling, and weather considerations.¹ This report describes the initial construction phase of a projected 2-year field evaluation of two alternative systems: sheet-applied elastomeric ethylene propylene diene monomer (EPDM) roofs and liquid-applied elastomeric coating on sprayed polyurethane foam (PUF) roofs.

Objective

The overall objectives of CERL's roofing studies are to (1) evaluate innovative roofing systems and materials to determine alternatives to BUR systems, (2) provide a means to improve Army roof performance and reduce life-cycle costs, (3) improve contractor quality control of BUR construction, and (4) develop guide specifications for selected alternative systems.

The specific objective of this report is to document the construction phase of a 2-year field evaluation of two types of alternative roofing systems: EPDM and liquid-applied elastomeric coating on sprayed PUF.

Approach

This study had the following steps:

1. Roof systems for a 2-year field evaluation were selected based on earlier CERL studies.²

¹ E. Marvin, et al., Evaluation of Alternative Reroofing Systems, Interim Report M-263/ADA071578 (U.S. Army Construction Engineering Research Laboratory, June 1979).

² Evaluation of Alternative Reroofing Systems.

2. A test plan was developed using standard test methods published by the American Society for Testing and Materials (ASTM), where available, and other tests developed by Government or private agencies, where needed.

3. Test sites were selected.

4. Test guide specifications were developed.

5. Instrumentation systems were designed.

6. The installation of the test roofing systems was monitored.

Mode of Technology Transfer

Data obtained during this study will impact on Corps of Engineers Guide Specifications (CEGS) 07530, Elastomeric Roofing (EPDM) (July 1980) and 07540, Elastomeric Roofing, Fluid Applied (April 1980).

2 PROCEDURE

Selection of Roof Systems

CERL selected two systems for testing: (1) a sheet-applied elastomeric EPDM, and (2) a foamed-in-place PUF with a protective coating. These systems were applied to the same building or adjacent buildings at each test site; a conventional BUR was also applied at the same site as a control.

Test Plan

The test plan was designed to determine what changes weathering would cause to the physical characteristics of the two alternative and the BUR systems. The test and control systems were instrumented so the following could be monitored and controlled:

1. Thermal conditions within the roof systems.
2. Weather conditions at the test site including temperature, humidity, and solar radiation.
3. Strains that occurred within the EPDM roof system.

The initial set of tests was designed to establish the physical characteristics of the materials at the time of application. Subsequent tests are scheduled at 6-month intervals over a 2-year period to establish a pattern of performance or to note changes in physical and mechanical characteristics. A final test of field-exposed samples is proposed at the end of 10 years.

The PUF, EPDM, and BUR characteristics of interest to this study are listed in Tables 1, 2, and 3, respectively. In addition to laboratory tests of field-aged samples, visual inspections will be made at regular intervals to check for changes in appearance, loss of coating adhesion, blistering, cracking, pinholing, or any evidence of mechanical damage from roof traffic or natural phenomena such as hail.

Test Site Selection

To ensure that the roof systems were subjected to as close to identical exposure conditions as possible, site selections were based on:

1. The availability of a building or adjacent buildings of similar construction and occupancy.
2. The availability of a local (in-house) engineer staff that could prepare contract drawings and administer the construction contract.
3. The availability of local (site) funding for the construction work.
4. The availability of buildings built with concrete structural deck systems (to comply with restrictions given in CEGS-07540).

Table 1

PUF Test Characteristics

<u>Tests at Beginning of Exposure Program</u>		<u>Remarks</u>
<u>Property</u>	<u>Test Method</u>	"Property" refers to physical properties of interest. These tests will establish a baseline standard for coatings so later tests can be compared to field-exposed samples.
<u>Coating</u>		
Adhesion		
Thickness	ASTM D 2157	
Brittle temperature	ASTM E 96	
WVT		
<u>Tests at Beginning and Intermittently During Program</u>		
<u>Foam</u>		
Density	ASTM D 1622	The material must not deteriorate or lose density. Moisture may enter from below (condensation) or above (leakage).
Water absorption	ASTM D 2842	
Water vapor transmission	ASTM C 355	
Compressive strength	ASTM D 1621	The foam must be capable of resisting normal movements over the life of the insulation. The foam must be capable of resisting foot traffic and other mechanical abuses. The foam must not move or change dimensionally to ensure that the system performance is not endangered.
Tensile strength		
Impact resistance		
Indentation strength	ASTM D 2856	
Closed-cell content	ASTM D 2166	
Dimensional stability		
<u>Field Tests and Monitoring</u>		
<u>Visual inspection</u>		Check for adhesion loss, blistering, cracking, flaking, peeling, pinholing, and hail damage. This test will amplify the visual test.
<u>Photomacrographic study</u>		
<u>Weather Data</u>		
Temperature		
Humidity		
Solar radiation		
Rainfall		
<u>Temperature Measurements</u>		
Thermocouples will be placed at the interface of the foam and the supporting deck and at the coating surface.		
<u>Strain Measurements</u>		
On coating surface at selected points at expected maximum and minimum strain.		These measurements will establish the range of strain magnitudes that the surface coating will be subjected to in service.

Table 2

EPDM Test Characteristics

<u>Test at Beginning of Exposure Program</u>		<u>Remarks</u>
<u>Property</u>	<u>Test Method</u>	
Ozone resistance	ASTM D 1149	"Property" refers to physical properties of interest. This group of tests will be used to predict weathering performance. The tests will be useful for comparison purposes at the end of the 2-year period to see how well they predicted the actual condition of the membrane materials.
<u>Tests at Beginning and Intermittently During Program</u>		These are tests to establish the basic physical characteristics that are typical to roof membranes. Any changes in these characteristics during service would signal aging, deterioration, and a reduction in lifetime expectancy. Abrasion resistance is necessary if the roof will experience regular foot traffic; seam strength is essential in one-ply systems; changes in hardness indicate a loss of plasticizer, oxidation, and decrease in resistance to mechanical damage; absorption and permeability are necessary characteristics if the membrane is used over existing roofing systems with possible moisture entrapment.
Abrasion	ASTM D 3389	
Seam strength	ASTM D 412	These measurements are needed to correlate with strain and temperature measurements.
Ultimate elongation	ASTM D 412	
Tensile strength	ASTM D 412	Previous studies indicate that these locations will give good data on movement within the membrane.
Water resistance		The thermocouple stack is a standard method of measuring temperatures in a building component. Thermocouples at strain gauge locations are needed to correct strain gauge output.
Absorption	ASTM D 570	
Permeability	ASTM E 96	This type of inspection (to include photographs) will record physical changes and/or appearances. Infrared photography will be used to determine any changes in the moisture content of the insulation.
<u>Field Tests and Monitoring</u>		
Weather Data		
Temperature		
Humidity		
Solar radiation		
Rainfall		
Strain Measurements		
Strain gauge measurements will be made at points on the centerline of the test area at 90 degrees to measure longitudinal and transverse strains. Measurements will also be made at corners, penetrations, and at the center of the perimeter.		
Temperature Measurements		
Thermocouples will be placed at the interface of the roof deck and insulation, and at the surface of the membrane at the strain gauge locations.		
Periodic Field Observations		
Visual inspection		
Nondestructive moisture measurement		

Table 3

BUR Test Characteristics

<u>Tests at Beginning of Exposure Program</u>		<u>Remarks</u>
<u>Property</u>	<u>Test Method</u>	
Asphalt	ASTM D 312	These tests will establish that the materials used to construct the membrane meet minimum ASTM standards.
Class mat	ASTM D 2178	
Surfacing	ASTM D 1863	This test will be done during the assembly operation to establish the quality and quantity of the membrane materials.
BUR assembly	ASTM D 3617	
<u>Field Tests and Monitoring</u>		
Weather Data		
Temperature		
Humidity		
Solar radiation		
Rainfall		
Strain Measurements		
Measurements will be made at selected points at expected maximum and minimum strains.		This test will reveal membrane movements.
Temperature Measurement		
Thermocouple "stacks" will be placed at strain gauge locations.		These tests are needed to correct strain gauge outputs.

Three Army installations that were representative of the geographical and climatic variation of the continental United States were chosen as test sites: Fort Lewis, WA; Fort Knox, KY; and Fort Benning, GA. These sites met most of the criteria, except that at Fort Benning, two of the structural deck systems were metal rather than concrete.

Test Guide Specification Development

An intensive literature search was made to determine how the physical properties and performance criteria of commercially available EPDM and PUF roof systems varied. Test guide specifications specifically designed for this program were prepared in accordance with a format recommended by the Office of the Chief of Engineers (OCE). It was found that as the specifications developed, a true nonproprietary specification was not possible. This was particularly true with coating specifications for the PUF systems.

Specifications for EPDM material were based on ASTM D 3253, Vulcanized Rubber Sheet for Pond, Canal, and Reservoir Lining. Specifications for PUF and coatings were developed based on information from the Naval Civil Engineering Laboratory (NCEL) and observations made at Cape Hatteras. Guide specifications for EPDM installation were based on the published literature of the Carlisle Tire and Rubber Company and discussions with Carlisle representatives and factory personnel.

All specifications included provisions for supplying materials for this study's sampling needs. Final project specifications and contract documents were developed by in-house engineers at the various site locations. Test guide specifications used in this study are in Appendix A. Contract specifications are in Appendix B.

Instrumentation Design

The criteria developed for the instrumentation systems required (1) a temperature profile through the system, (2) strain measurements in the EPDM, and (3) automatic data reading.

Criterion Number 1 was met by installing a vertical stack of thermocouples through the system. These thermocouples were located at the various system interfaces, including the deck/insulation interface and the top of the membrane (for the EPDM system) and the deck/insulation interface and the top of the coating (for the PUF system).

Criterion Number 2 was far more difficult to meet. Several strain gauge types were tested without success. A flexible metal transducer was devised that would be more sensitive to the very small strains involved, but did not prove useful. Mercury-filled strain gauges are presently under study.

Because the site locations were widely separated, it was decided that all data had to be recorded automatically in a way which required only minimum attention from installation personnel (Criterion No. 3). A device was acquired that would record the data on magnetic tape automatically and at a preselected interval.

Appendix C describes the study's instrumentation system.

Contracting Procedure

The roof systems were procured by normal contracting methods using public bidding. Although regular advertising methods were used, there appeared to be a serious lack of contractor interest. Only a limited number of bids was received at each location. It is speculated that bidders may have been discouraged (1) by the experimental nature of the systems, (2) because the roofs, in general, were small, and (3) by bidding documents which indicated that the work would be very closely inspected, both during and after construction.*

Table 4 summarizes the contract amounts for the three locations and the unit costs for the various systems.

After contracts were awarded, but before the actual work began, a preconstruction conference was held at each site. Representatives from CERL as well as the Contracting Officer and the Contractor and Subcontractors were present. The local engineering inspectors were also invited. All specifications and drawings were carefully reviewed and the aims and goals of the experimental aspects of the project were explained and discussed. Particular emphasis was placed on the fact that these projects were to serve as demonstrations for future material and specification selection, that requirements for application procedures and materials would be very closely monitored, and that nonconforming work would be rejected.

* Bids for the EPDM and BUR systems at Fort Knox were received too close to the end of the Fiscal Year (FY) 79 for the funds to be obligated, so only the PUF roof was contracted at Fort Knox.

Table 4

Total Contract and Unit Costs

<u>Location</u>	<u>Roof System</u>	<u>Contract</u>	<u>Sq Ft (m²)</u>	<u>\$/Sq Ft (\$/m²)</u>
Fort Benning	BUR	\$ 5,900	1,300 (121)	4.54 (48.87)
	EPDM	22,106	3,100 (288)	7.13 (76.75)
	PUF	14,394	2,600 (241)	5.54 (59.64)
Fort Lewis	BUR	44,190	6,500 (604)	6.80 (73.20)
	EPDM	57,700	9,000 (836)	6.41 (69.00)
	PUF	56,700	7,000 (650)	8.10 (87.19)
Fort Knox	PUF	13,850	1,750 (163)	7.91 (85.15)

3 TEST ROOF CONSTRUCTION

Fort Lewis

At Fort Lewis, a single building was used to install all three test systems. This building had three separate and distinct roofs: the main building had both a two-story and a single-story section; the wing connected to the single-story section was separated by a seismic joint. The two-story section was designated as Area A, the single-story section as Area C, and the wing as Area B. Figure 1 shows the building arrangement.

The existing roofs on Areas A and B were BUR with gravel surface over two courses of 1-1/4-in.- (32-mm)- thick wood fiberboard insulation set in an asphalt floodcoat on a sloping concrete roof deck. The eaves were a continuous 2 x 6 coping block; there were aluminum gravel stops on all four sides of Area A and on three sides of Area B. The fourth side of Area B had a copper sheet metal bellows type earthquake joint set on continuous wood coping blocks. The condition of the insulation in Areas A and B varied from damp to saturated with moisture.

The existing roof on Area C had a gravel surface over BUR on 1- to 9-in.- (25- to 229-mm)- thick lightweight concrete. This surface was over 2-1/2-in. (64-mm) wood fiberboard insulation (two courses at 1-1/4 in. [32 mm]), which in turn was placed on an asphalt floodcoat on a dead-level concrete roof deck. The condition of the insulation in Area C varied from damp to saturated with moisture. The eaves were aluminum gravel stops on continuous wood coping blocks. One end of the roof was aluminum reglet flashed and counter-flashed to a masonry wall of the two-story portion of the structure; part of one side mated to the copper bellows seismic joint between Areas B and C.

Area A

Materials

The contract for Area A specified that the existing roofing, flashing, gravel stops, and insulation be removed. Gravel stops were to be reinstalled as part of the new system.

The system selected for Area A was an EPDM synthetic rubber manufactured by Carlisle Tire and Rubber Company. The contract specified:

1. Priming the concrete deck.
2. Installing one ply of No. 43 asphalt-saturated and coated inorganic base sheet in hot asphalt.
3. Setting 2-1/2 in. (64 mm) of rigid closed-cell inorganic board in hot asphalt.
4. Bonding a 60-mil- (1.5-mm)- thick EPDM membrane to the insulation surface.

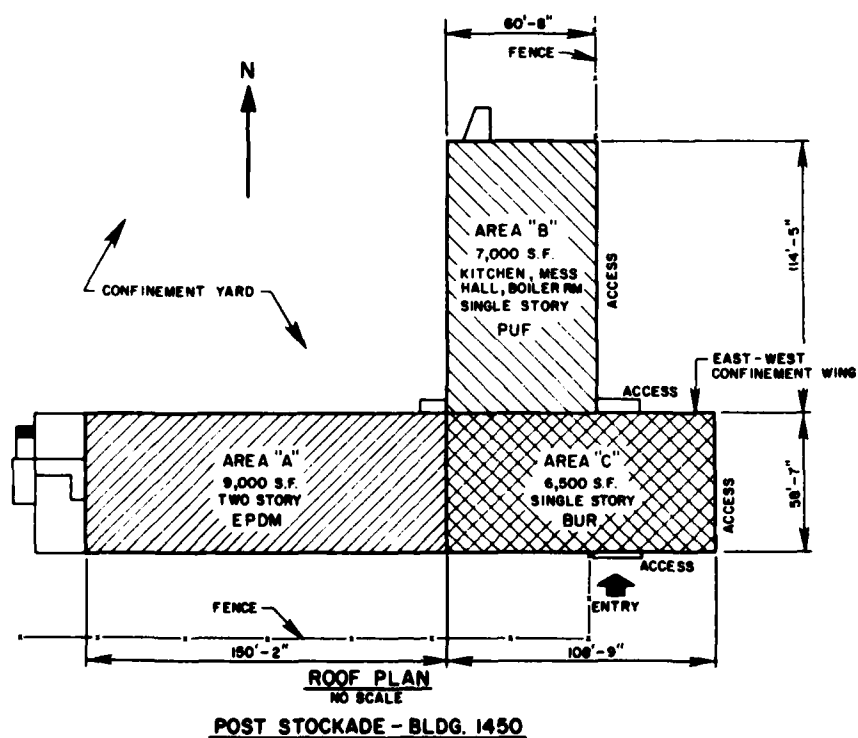
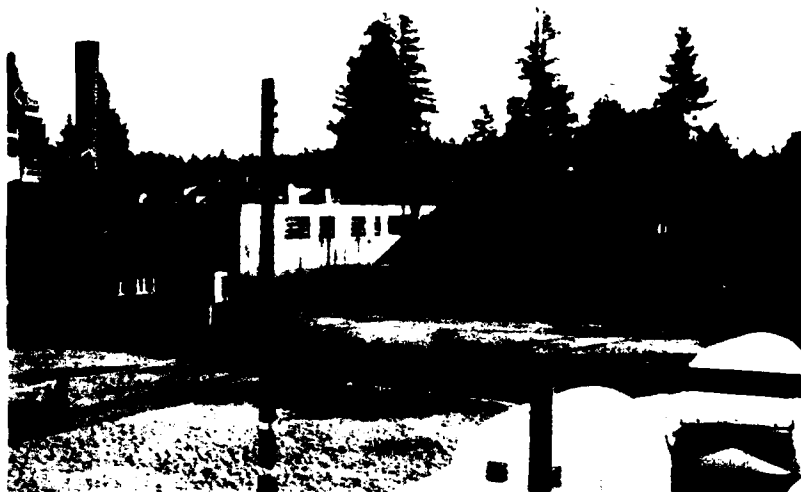


Figure 1. Building selected for test roofing at Fort Lewis.

The design insulating value of the board stock was R-19. As required by the manufacturer, the membrane was mechanically fastened at the perimeter and to transverse nailers, subdividing the roof into maximum areas of 1600 sq ft (149 m²).

Actual materials used to install the EPDM test system were:

Asphalt: Georgia Pacific Type III, 460°F (238°C) EVT

Base Sheet: Owens Corning Fiberglas Base Sheet

Insulation: Apache standard with asphalt-saturated organic felt facer sheets.

Discussion

Construction of the test systems was scheduled to begin on 9 October 1979, and the first removal of the existing roof system actually started on that day. The inspection records show that on 9 October materials had not yet been submitted for approval and that the asphalt kettle was not equipped with the temperature control and recording device required by the specifications. The removal work continued for the next several days, but on 12 October the job was closed down until the controllers for the kettle could be purchased and installed. The area of the roof where removal had taken place was covered with polyethylene sheeting. Rolls of felt were used to ballast the polyethylene.

On 23 October, the contractor was notified that the temporary protection had blown away and that the rolls of felt were now wet and had to be removed from the job site. Water was leaking into the building. Rain continued to hamper the work, and the job was finally shut down for the winter. The contractor provided a temporary roof consisting of one ply of felt with temporary flashings to seal the perimeter of the roof. The job records indicate that the contractor was still having difficulty locating the temperature controller for his kettle when the job was shut down.

Work resumed on 30 April 1980. The vapor barrier was repaired where needed and the insulation and the first rolls of EPDM were installed. A representative of the EPDM manufacturer was on the job to instruct the contractor in proper installation procedures. However, even with the representative at the site, the record indicates that the contractor failed to completely remove the talc coating from the EPDM sheets before the seam adhesive was applied. Daily reports also indicate that the contractor had problems with folds in the EPDM sheet and bare areas between membrane and deck, and failed to stir the materials or allow the open time for adhesives and sealants recommended by the manufacturer. This contractor had no previous experience installing elastomeric roof systems.

By 9 May, all of the EPDM had been installed. The contractor then began to remove the area of roof that was to receive the BUR application, while he

completed the metal work and nailing of the EPDM to the grid. Many blisters were evident beneath the EPDM membrane. They seemed to result from air being trapped under the sheet while it was being adhered to the insulation.

Area B

Materials

The contract for Area B specified that the existing roofing, flashing, and insulation be removed down to the concrete roof slab. Gravel stops and earthquake bellows were to be reinstalled as part of the new system.

The system selected for Area B was sprayed-in-place PUF, coated with urethane coating and granules. The contract specified:

1. Priming the concrete deck.
2. Installing one ply of No. 43 asphalt-saturated and coated inorganic base sheet in hot asphalt.
3. Spraying the PUF to a thickness adequate to provide a thermal resistance of R-19.
4. Applying a granule-embedded silicone or catalyzed urethane coating.

Actual materials used to install the PUF test system were:

Asphalt: Georgia Pacific Type III, 460°F (238°C) EVT

Base Sheet: Owens Corning Fiberglas Base Sheet

PUF: Foam Systems Co., Polyurethane Insulation #234

Coating: Iratethane Weatherflex; 16 mils (0.4 mm) of a catalyzed urethane base coat, with 4 mils (0.1 mm) of a Hypalon* top coat.

Granules: 3M Co. C-68

Discussion

Work on the area to receive the PUF started on 20 May 1980, when the existing roof system was removed. The stripping operation was completed on 23 May, leaving the existing vapor barrier to provide temporary protection for the building.

From 17 to 18 June, the PUF deck area was given a final cleaning. Foaming began on 20 June; about half the area was covered that day. The base coat was applied, but final coating was delayed because of questions concerning the granules to be incorporated in the final coating. The balance of the foaming and base coating application was completed on 21 June. The top coat and

* Hypalon is a registered trademark of the E. I. DuPont de Nemours Co., Inc., for their brand of chlorosulfonated polyethylene (CSPE) coating material.

granules were applied on 27 and 28 June without difficulty, except for a slight delay caused by moisture on the roof.

Area C

Materials

The contract for Area C specified that the existing roofing, flashing, lightweight concrete fill, rigid board insulation, and earthquake copper bellows be removed down to the concrete roof slab. New aluminum reglet flashing and counter-flashing were specified; existing gravel stops and copper bellows were to be reinstalled.

The system selected for Area C was a four-ply BUR. The contract specified:

1. Priming the concrete deck.
2. Installing one ply of No. 43 asphalt-saturated and coated inorganic base sheet in hot asphalt.
3. Providing lightweight asphaltic concrete insulating fill and two courses of rigid insulating board set in hot asphalt.
4. Applying a four-ply BUR with a mineral surface cap sheet.

Actual materials used to install the BUR control system were:

Asphalt: Georgia Pacific Type III, 460°F (238°C) EVT

Base Sheet: Owens Corning Fiberglas Base Sheet

Insulation: Pre-beveled and cut rigid polystyrene foam board manufactured by Western Insulfoam Corp., Fed. Spec. HH-I-524B, Types I and II, Class A.

Felt: Owens Corning Perma-Ply No. 11 glass fiber felt

Cap Sheet: Owens Corning Perma Cap

The BUR was installed in two phases: (1) a three-ply shingled membrane was applied to the insulation surface; then (2) the mineral-surfaced cap sheet was installed, in single-ply fashion, in lengths of material cut to about 12 ft (3.6 m). This type of construction is commonly used on the West Coast.

Discussion

Work on the area to receive the glass felt BUR started on 13 May 1980 when removal of the existing roof started. By 17 May, a vapor barrier had been installed over two-thirds of the area. The vapor barrier was completed by 19 May. The daily reports indicate problems with material storage (improper coverings) and failure to provide protective glaze coatings for the vapor barrier after it was installed.

The BUR area was left for several days with only the vapor barrier for protection. Large fishmouths at the east end of the area allowed water to enter below the barrier and the barrier had to be repaired. Work resumed on 29 May with the installation of wood nailers and tapered insulation. Delays were encountered because the contractor attempted to substitute an unapproved insulation material. Problems also developed when the contractor did not follow the manufacturer's instructions for melting holes into the tapered polystyrene insulation. Records indicate the work was not inspected carefully and that there were some delays in submitting shop drawings, samples, etc.

The Job Inspector was also not familiar with the roofing systems or the job specifications. As a result, this test system was not installed to the full job specifications.

Fort Benning

Two buildings were selected at Fort Benning for installation of the test systems. Building 2823 had two sections; one section was larger and about 2 ft, 9 in. (0.8 m) taller than the other section. The existing roofs were BUR with gravel surface over insulation board adhered to the steel deck with asphalt. Building 2806 was smaller than Building 2823. Its deck was concrete, and it was a one-story building.

The high roof of Building 2823 received Carlisle EPDM (fully adhered); a four-ply organic felt BUR was applied to the low roof. Building 2806 received a sprayed PUF roof covered with silicone coating and granules.

Figure 2 shows the arrangement of Building 2823; Figure 3 shows Building 2806.

Building 2823

Materials

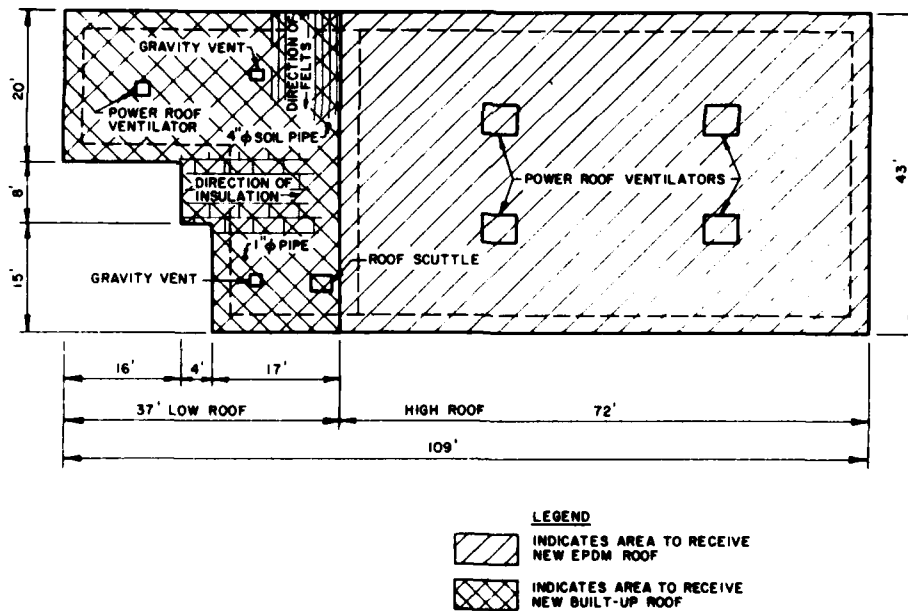
The contract for Building 2823 specified that a cellular glass or composite board insulation be mechanically fastened to the steel deck and covered with four-ply organic felt BUR with a gravel surface on the low portion and a fully adhered 60-mil- (1.5-mm)- thick Carlisle EPDM on the high portion. The design value of the heat transmission coefficient of the completed roof was 0.050. As required by the manufacturer, the membrane was mechanically fastened at the perimeter and to nailers around the penetrations.

Actual materials used to install the BUR and EPDM test systems were:

Asphalt: Celotex Steep Asphalt #220

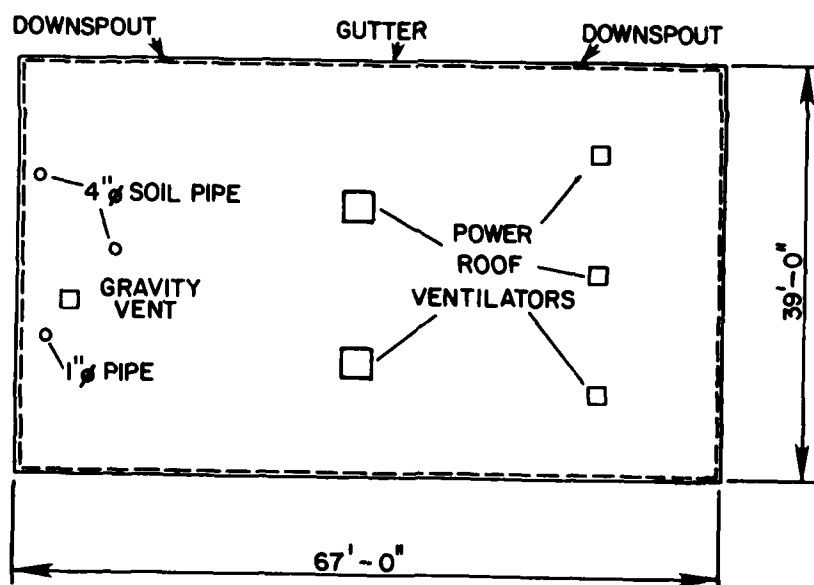
Felt: Celotex No. 15 perforated organic asphalt-saturated felt

Insulation: 3-in. (76-mm) Apache Millox Composite Board



ROOF PLAN - BLDG. 2823

Figure 2. Building selected for EPDM and BUR at Fort Benning.



ROOF PLAN - BLDG 2806

Figure 3. Building selected for PUF roofing at Fort Benning.

Building 2806

Materials

The contract for Building 2806 specified that the completed roof have a heat transmission coefficient of 0.050. The concrete deck was to be covered with a two-ply organic felt and asphalt vapor barrier, sprayed with PUF to the necessary thickness, and coated with either General Electric 2-component silicone, Dow Corning 1-component silicone, or Irathane Weather/Flex Plus, and covered with No. 11 screen size ceramic-coated granules.

Actual materials used to install the PUF test system were:

Asphalt: Celotex Steep Asphalt No. 200

Felt: Celotex No. 15 perforated organic asphalt-saturated felt

Foam: Witco Isofoam SS0545

Coating: Dow Corning 3-5000 Silicone Construction Coating

Granules: 3M Company C-68

Discussion

Construction began on the EPDM area of Building 2823 on 26 November 1979. Extra splices that were not indicated on the shop drawings were used around curbs, and the perimeter nailer was thicker than the insulation. The contractor used a tapered filler strip to compensate for this difference in thickness. A small amount of damage occurred to the installed EPDM sheets during the removal of subsequent areas of the existing roofing. All of the new insulation was installed by 30 November, but cold weather delayed further work until 4 December, when two additional pieces of EPDM were installed. The final section of EPDM was installed on 5 December.

Although the roof was covered, flashing work at the ventilators and perimeter was not complete. The balance of the job progressed very slowly; on 13 December, the perimeter metal was still not complete.

The spray equipment for the PUF for Building 2806 arrived at the job site on 10 December; the actual application took place on 11 December. Eight 2-ft (0.61-m) square boxes were placed on the roof surface to collect foam samples. The spraying operation started at the northwest corner of the building; the foam was applied in a north-to-south direction. The operator changed the application pattern when it became apparent that it was creating low areas that would block the natural flow of water from west to east. The finished foam surface varied from "popcorn" to "tree bark." (These are descriptive terms used to classify foam surface condition. "Verge of popcorn" is considered barely acceptable; "popcorn/tree bark" is not considered acceptable according to Dow Corning's Visual Standards for Polyurethane Foam to Receive Dow Corning Silicone Construction Coating.)

When samples of the coating base coat were removed, voids were evident in the material, indicating that the foam surface was too rough to coat. The

base coat was not filling or bridging the voids in the foam surface. This happened because the temperature was too low and humidity too high for satisfactory application.

The rejected areas were removed on 12 December, refoamed, and recoated with base coating material. The base coating was still not completely satisfactory, since the foam surface could still be seen through the coating. The coating surface was also damaged by persons walking on the roof. After repairing the coating, the contractor attempted to apply the finish coat and granule surface using sand blasting equipment to distribute the granules. Unfortunately, the equipment had not been modified and the pressures were too high. The 68 psi (0.468 N/mm^2) pressure propelled the granules with enough force to rupture the coating and blow the granules off the roof. The contractor then attempted to apply the granules by hand, and found that the rough surface of the foam and base coat required considerably more finish coat and granules than he had anticipated. An attempt to use the sand blasting equipment with reduced pressure did not work. About half the roof was coated on the first day of coating work. The results were inspected on 15 December, and it was evident that the coating had not filled or bridged the voids in the foam surface.

The problems encountered during the application of the EPDM and PUF test systems most likely occurred because the contractor was not familiar with either system. As a consequence, he did not comply with all of the technical requirements of the specification. These problems were probably compounded by the fact that the construction inspectors were also unfamiliar with the standards for the test systems (as recommended by the manufacturers).

The application of the BUR was not observed.

Fort Knox

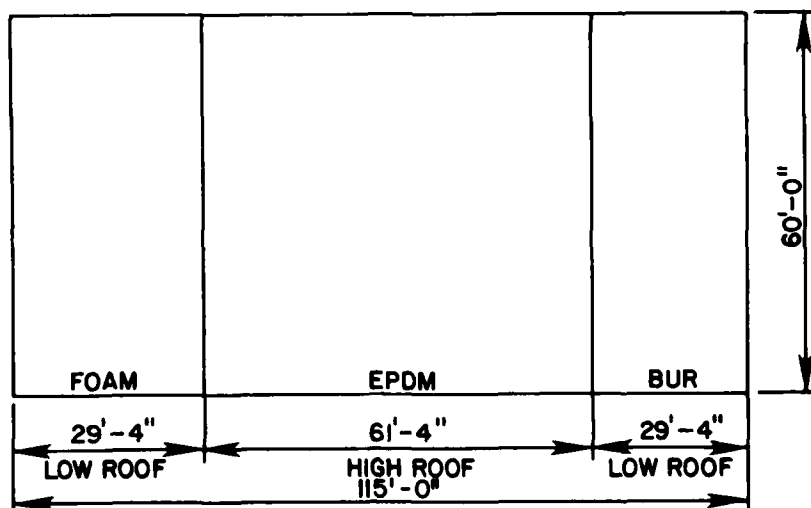
At Fort Knox, Building 6576 was selected for installation of the test systems (Figure 4). This building had three sections: a large central section about 78 in. (1.98 m) above two smaller end sections. The west end was to receive the PUF, the central section the EPDM, and the east section the BUR. The existing roofing consisted of coal-tar BUR with gravel surface over 2-in. (51-mm) gypsum plank deck above rigid insulation board. As stated previously, only the contract for the PUF work was awarded.

The contract specified that the existing roof membrane and all accessories be completely removed. A single ply of asphalt-saturated base sheet, nailed to the gypsum plank, was to be installed as a vapor barrier. Foam thickness was specified as that necessary to attain a heat transmission coefficient of 0.050. Coating was specified as either General Electric 2-component silicone, Dow Corning 1-component silicone, or Irathane Weather/Flex Plus, with a covering of No. 11 screen size ceramic-coated granules.

Actual materials used to install the PUF test system were:

Base Sheet: GAF Universal Base Sheet

Foam: Reichhold Chemicals, Inc., RCI Polylite No. 98-137/34-841



ROOF PLAN - BLDG 6576

Figure 4. Building selected for test roofing at Fort Knox.

Coating: Dow Corning 3-5000 Silicone Construction Coating

Granules: 3M Co., C-68

Discussion

Preparation for the application of the PUF began on 2 November 1979 with the removal of the old BUR. Four large holes found in the gypsum deck had to be repaired before the work could proceed. On 3 November, half the roof was covered by foam; winds were brisk, and some difficulty was encountered in keeping the foam off of nearby vehicles. The balance of the roof was foamed the next day. Ridging problems occurred that could not be explained, and a shifting wind made it very difficult to control the overspray. The ridges were removed by sawing, low areas were refoamed, and the base coat of silicone was applied the following day. Again, windy weather made spraying difficult. Plywood shields were used to help control overspraying during coating and foaming operations.

The final top coat and granules were applied on 6 November. Windy weather made it impossible to get an even application. Premature walking on the surface resulted in coating/granule loss, but this was easily repaired.

4 PHYSICAL PROPERTIES OF MATERIALS AT THE TIME OF CONSTRUCTION

Foam Roofs

Initial test results (Table 5) indicated that the lowest density foam was installed at Fort Benning, but the lowest compressive strength occurred in the foam installed at Fort Lewis. The Fort Lewis foam cannot be considered as having met the specified compressive strength of 40 psi (27.6 N/cm²), while the foams at Forts Benning and Knox exhibited values which were considerably higher. The high tensile strength at Fort Benning indicates better interlayer adhesion than at either Knox or Lewis.

In general, the polyurethane foam at Fort Lewis was found to be slightly different in cell structure and material composition from the foams at Forts Benning and Knox. This difference is indicated by lower strength and closed cell content as well as higher water vapor transmission and dimension change.

Indentation strength reflects the surface condition. The high value at Fort Lewis reflects the hardness of the urethane coating (85) as opposed to the silicone (45). These values are as published by the respective coating manufacturers. Impact strength also reflects the surface condition. The difference in values between the top and base coats at Fort Lewis indicates that a severe hail storm could rupture the Hypalon top coat while leaving the urethane base coat intact. Indentation and impact strengths at Fort Benning are disproportionately low compared to the compressive strengths at the three locations. Compressive strength reflects the interior condition of the foam, since the surface is removed to obtain good bearing for the compressive test. Some of the Fort Benning samples had irregular surfaces caused by numerous spots with lower than average density foam in the top layer only. These low-density portions appeared to be slightly resin lean (more polyol than isocyanate) and showed some evidence of moisture reaction either from failure of the spray equipment moisture trap or presence of small amounts of moisture on the surface of the underlying foam at the time of application of the final layer. This condition may be limited to the samples rather than the entire roof; however, comments from the coating manufacturer indicate this condition does exist to some extent on the roof.

EPDM Roofs

The values shown for the EPDM in Table 6 indicate good quality rubber sheet. The seam strength appears to be very low, however, which may be due to the improper seaming techniques discussed in Chapter 3. A minimum peel strength value of 5 lb/in. (0.876 N/mm) of width would be more appropriate. The shear strength at Fort Benning of 18 lb/in. (3.5 N/mm) of width is only 20 percent of the sheet strength, while that at Fort Lewis of 28.7 lb/in. (5.02 N/mm) of width is 29 percent of sheet strength. According to the manufacturer, the shear strength of the seam should be 80 percent of the sheet strength. Observations of the seam area after separation indicated that the sheet was not completely cleaned of its talc coating before the seam cement was applied.

Table 5
Polyurethane Foam Roofing -- Initial Physical Properties

Property	Test Method	Fort Knox	Fort Benning	Fort Lewis
Density lb/ft ³	ASTM D 1622 Average Range	3.11 2.92-3.40	2.87 2.77-3.04	3.07 2.89-3.31
Compressive strength, lb/in ²	ASTM D 1621 Average: Range	62 51-76	53 44-58	39 35-41
Indentation strength, lb/in ²	USBR Yield, Average Range Break, Average Range	78 62-89 94 81-105	68 46-82 79 72-85	65 54-75 No break at 1/2 inch deflection
Impact strength, grams	USBR Average Range	370 328-418	210 194-225	Top 140, Base 650 Top 120-192, Base 623-675
Tensile strength, lb/in ²	USBK Average Range	64 50-93	78 62-89	55 42-64
Water absorption lb/ft ² surface area	ASTM D 2842	0.01	0.06	0.04
Coating vapor transmission, Perms	ASTM E 96 Water Method	2.4	2.2	1.6

Table 5 (Cont'd)

Property	Test Method	Fort Knox	Fort Benning	Fort Lewis
Coating adhesion, lb/in ²	NAVY CEL	Average	160	Top probe adhesion problems -- to be retested. Base 104
		Range	123-192	Top 157-192, Base 94-117
Coating glass transition, °F	ASTM D 3418	-189	-189	-67
Coating thickness, mils	USDR	Average	30	20
		Range	20-40	10-25
Coating brittle temperature, °F	ASTM D 2137	-98	below -104	below -95
Foam water vapor transmission, Perms	ASTM C 355	0.86	1.05	1.28
Closed Cell content of foam, percent	ASTM D 2856	Corrected	97.0	96.0
		Uncorrected	92.1	91.4
Dimensional stability of foam, Percent Volume Change at 158 °F	ASTM D 2166	30% RH	-0.7	0.85
		1 day	-0.5	2.1
		7 day	-0.4	2.0
		14 day		
		100% RH	9.0	60.2
		1 day	11.2	67.3
		7 day	12.3	45.9
		14 day	18.4	

Table 6

EPDM Rubber Roofing -- Initial Physical Properties

Property	Test Method	Fort Benning	Fort Lewis
Tensile strength, lb/in ²	ASTM D 412	Average Range 1585 1445-1705	1705 1640-1845
	Transverse	Average Range 1525 1405-1650	1645 1135-1820
Elongation, %	ASTM D 412	Average Range 540 475-640	505 480-540
	Transverse	Average Range 580 530-640	515 480-580
Hardness, Shore A	ASTM D 2240	Average Range 58 56-60	57 56-58
Ozone Resistance	ASTM D 1149	No Cracks	No Cracks
Water Absorption, Wt %	ASTM D 570	+ 0.5	+ 0.4
Water Vapor Transmission, Perms	ASTM E 96 Water Method	0.06	0.04
Glass Transition, °F	ASTM D 3418	-60	-65
Abrasion Loss, grams/1000 rev	ASTM D 3389	Average Range 0.19 0.15-0.22	0.19 0.1-0.21
Seam Strength, lb/in width		Peel Shear 0.8 18.0	2.5 28.7

Built-Up Roofs

The characteristics of the built-up roof assemblies (Table 7) indicate that the breaking strength of the glass fiber system at Fort Lewis was considerably higher than that of the organic felt system at Fort Benning. This is to be expected based on the characteristics of the two felt materials. Tests indicate that excessive asphalt was used in the Fort Lewis assembly. Contrary to specification requirements, the aggregate used at Fort Benning was crushed and excessively angular, and was not properly graded. However, such aggregate has been used successfully in Georgia for many years. Except for penetration value of the Fort Lewis asphalt at 77°F (25°C), the asphalt at both locations met the requirements of ASTM D 312 type III.

Complete test results are given in Tables 5, 6, and 7.

Table 7
Asphalt Built-Up Roofing
Initial Physical Properties

Property	Test Method	Fort Benning	Fort Lewis
Assembly characteristics			
	ASTM D 3617		
Average number of plies		4.2	3.2
Membrane mass, lb/100 ft ²		173	251
Asphalt mass, lb/100 ft ²		123	221
Lap spacing, inches, average		7.5	11.0
Roof surfacing characteristics			
	ASTM D 1863		
Hardness, percent loss after tumbling		9	N/A
Unit weight, lb/ft ³		97.8	N/A
Gradation, percent passing 3/4 in.	100	100.0	N/A
1/2 in.	90 to 100	82.8	N/A
3/8 in.	40 to 70	25.2	N/A
No. 4	0 to 15	0.6	N/A
No. 8	0 to 5	0.3	N/A
Roofing felt characteristics			
	ASTM D 226 and D 2178	D 226	D 2178
Breaking strength, lb/in. width, with fiber	min 30 22	8.4	35.6
across fiber	min 15 22	8.0	29.0
Pliability at 77°F (1/2-in. radius)	no cracks no fail	Pass	Pass
Openness of perforations, percent	min 30 N/A	100	N/A
Loss on heating at 105°C, 5 hour, percent	max 4 N/A	6.0	N/A
Weight, lb/100 ft ²	min 13 9.7	11.9	12.2
Holes/ft ²	min 115 N/A	144	N/A
Asphalt Characteristics			
	ASTM D 312		
Flash point (COC),* °F	min 437	585	580
Softening point, °F	185 to 205	195	194
Penetration at 77°F	15 to 35	17	13
Penetration at 115°F	max 90	32	31
Solubility in TCE, percent	min 99	99.8	99.8
Ductility at 77°F, cm	min 2.5	4	4

* Cleveland Open Cup

5 SUMMARY

Three Army installations were selected for construction of experimental elastomeric roofing systems. Sprayed PUF roofs coated with sprayed elastomeric material were installed on buildings at Forts Benning, Knox, and Lewis. Sheets of EPDM synthetic rubber were installed on buildings at Forts Benning and Lewis. BUR systems (for control purposes) were installed on buildings at Forts Benning and Lewis.

The completed roofs were satisfactory for the purpose of this investigation, which was to demonstrate the capabilities of the elastomeric materials to withstand weathering under normal service in different climates. Although the specifications were not followed in all respects, the three roofs are expected to perform as intended.

APPENDIX A:

CERL ROOFING STUDY TEST GUIDE SPECIFICATIONS

BUILT-UP ORGANIC FELT ROOFING

CERL ROOFING STUDY TEST GUIDE SPECIFICATION

FOR BUILT-UP ORGANIC FELT ROOFING

(A) (B)

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of (C) this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.1 American Society for Testing and Materials (ASTM) publications:

C 208-72	Insulating Board (Cellulosic Fiber), Structural and Decorative.
D 41-78	Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
D 226-77	Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
D 312-78	Asphalt Used in Roofing.
D 517-70 (R1976)	Asphalt Plank.
D 1751-73	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
D 1863-77	Mineral Aggregate Used on Built-Up Roofs.
D 2626-73	Asphalt-Saturated and Coated Organic Felt Base Sheet Used in Roofing.
D 2822-75	Asphalt Roof Cement.
D 3617-77	Sampling and Analysis of New Built-Up Roof Membranes.

2. GENERAL: Asphalt bitumen built-up roofing shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage of Materials: Roofing materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Felts and roll roofing shall not be exposed to any moisture before, during, or after delivery to the site. Felts and roll roofing shall be stored in an enclosed building or in a trailer, stacked on end, and maintained above 50 degrees F for 24 hours immediately before laying.

2.2 Coordination Requirements: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations the same day felts are installed. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is water-proofed the same day with the complete roofing system.

2.3 Preparation Requirements: The entire roof-deck construction of any bay or section of the building shall be completed before roofing work is begun thereon. Roofing on lightweight insulating concrete shall not be scheduled until the insulating concrete passes the air-dry density test specified therefor in SECTION: CONCRETE. Roofing on structural concrete or concrete fill shall not be scheduled until frothing or bubbling does not occur when hot bitumen is applied to the deck and until the hot bitumen sticks tightly to the deck. Items penetrating the roof shall be secured in position and properly prepared for flashing.

2.4 Preparation for Reroofing: Existing roof deck shall be stripped of roofing membrane, insulation, vapor barrier, cants, embedded flashing, nails, fasteners, and deteriorated nailers. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weather-proofed at end of each working day.

2.5 Application Requirements: Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. The roofing or flashing shall be applied to a smooth and firm surface free from ice, frost, moisture, dirt, and foreign materials. Application of roofing shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40 degrees F.

2.6 Bituminous-plastic-type flashings installed in accordance with these specifications shall be used throughout unless otherwise specified or indicated. Metal flashings are specified in SECTION: SHEET METALWORK, GENERAL.

3. SUBMITTALS

3.1 Certificates of Compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the SPECIAL PROVISIONS.

3.2 Manufacturers Installation Instructions shall be submitted and approved prior to delivery of materials to the site. Instructions shall specify acceptable range of bitumen application temperatures. Bitumen manufacturer shall specify maximum temperature for holding bitumen in a heated condition.

3.3 Temperature Control Equipment. Contractor shall submit manufacturer's literature on the automatic temperature recorder and automatic thermostatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting that the recorder, automatic temperature control, and portable thermometer were each tested immediately prior to shipment to the site and that all operate within the accuracy tolerances given in the manufacturers specifications. Temperature control and recording equipment shall be in proper working condition during use.

3.4 Samples. The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

- Felts - 7-ft sample from end of each roll used
- Bitumen - 10 pounds of each type used
- Primer - 1 gallon
- Bituminous cement - 1 gallon
- Surfacing materials - 100 pounds
- Nails, fasteners, and anchors - 1 pound of each type, size, and style
- Premolded filler strip - 1 strip 6 feet long
- Asphalt plank - 1 square foot

4. MATERIALS:

4.1 Asphalt Primer: ASTM D 41.

4.2 Asphalt: ASTM D 312 as follows:

4.2.1 Type I on slopes up to and including 1/2 inch per foot.

4.2.2 Type II or Type III on slopes above 1/2 inch per foot up to and including 1 inch per foot.

4.2.3 Type III on slopes above 1 inch per foot up to and including 3 inches per foot.

4.3 Cants shall be made from treated wood or treated fiberboard and shall reduce the angle covered into two equal angles. Treated wood shall be of water-borne preservative-treated material as specified in SECTION: ROUGH CARPENTRY. Fiberboard shall conform to ASTM C 208 treated for moisture resistance by integral treatment with wax or other sizing or with bituminous impregnation.

4.4 Felt shall be the asphalt-saturated type and shall conform to the following requirements:

4.4.1 Roofing Felt: ASTM D 226, Type I.

4.4.2 Asphalt-Saturated Base Sheet: ASTM D 2626, Type I or II.

4.5 Nails, Fasteners, and Anchors shall be an approved type recommended by the roofing felt manufacturer. Fasteners for securing roofing felts to mineral-fiber, expanded perlite or fiberboard insulation, concrete, and gypsum surfaces shall provide a minimum holding power of 20 pounds each when installed.

4.6 Roofing Cement: ASTM D 2822, Type I.

4.7 Aggregate for Surfacing: ASTM D 1863. (D)

4.8 Premolded Filler Strip: ASTM D 1751, minimum 3/8 inch thick.

4.9 Asphalt Plank: ASTM D 517, _____ inch thick, mineral surfaced. (H)

5. ASPHALT BUILT-UP 4-PLY ORGANIC ROOFING (E) (F)

5.1 On Precast-Gypsum, Cast-In-Place Gypsum, or Insulating Concrete Surfaces: One ply of base sheet lapped in accordance with Table I shall be laid, without mopping, at right angles to the direction of the roof slope and fastened in accordance with Table II. Three plies of roofing felt shall be immediately laid shingle-fashion in hot solid moppings of asphalt. Each ply shall be lapped as specified in Table I [and fastened in accordance with Table II]. The flashings shall be installed and the flood coat and surfacing applied.

5.2 On Concrete or Insulation Surfaces: Four plies of roofing felt shall be mopped in solid with hot asphalt. Felts shall be laid shingle-fashion at right angles to the direction of the roof slope and lapped in accordance with Table I [and fastened in accordance with Table [II] [III]]. The flashings shall be installed and the flood coat and surfacing applied.

6. APPLICATION OF ROOFING:

6.1 General Requirements: The entire roofing system, including aggregate surfacing, shall be finished in one operation up to the line of termination at end of day's work. Application of roofing shall immediately follow application of insulation as a continuous operation. Phased construction will not be permitted. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen.

6.2 Detail Requirements:

6.2.1 [Prior to application of roofing, joints in precast concrete decks shall be covered with a 4-inch strip of roofing felt, embedded in and coated with bituminous cement. Concrete surfaces to receive asphalt products shall be primed at a rate of not less than 1 gallon per square. Bitumen shall uniformly cover all roof areas to be mopped to provide effective bond.]

6.2.2 Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

6.2.3 Bitumen stops formed of edge envelopes shall be installed at eaves and rakes. Envelopes shall be formed of two 18-inch-wide layers of roofing felt. Nine inches of the width shall be attached to the roof surface with 9 inches extending beyond the edge. The first layer shall be applied in a 4-inch-wide layer of roofing cement and nailed 1/2 inch from the roof edge at 6-inch spacing. The second layer shall be applied to the first in a 9-inch-wide mopping of bitumen. The free edges shall be protected from damage throughout the roofing period.

6.2.4 Application and holding temperatures shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers. Each layer of roofing felt shall be laid in not less than 15 pounds of asphalt per square or more than 25 pounds of asphalt per square. Kettlemen shall be in attendance at all times during the heating to insure that the maximum temperature is not exceeded.

6.2.5 Layers of roofing shall be laid free of wrinkles, creases or fish-mouths, at right angles to the slope of the deck, immediately behind the applicator. The surface of the felts shall be broomed-in full width to obtain complete adhesion between plies and to eliminate air pockets. Brooms shall have soft bristles and shall be discarded when the bitumen build-up on the fiber prevents application of equal pressure across the broom width on felts. The method of mopping a half-sheet width and turning the sheet back to mop under the other half will not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 4 inches, or to the top of the cant strip. After the last ply of roofing felt is applied, the edge envelope shall be formed by folding back and mopping each layer. The gravel stop, specified in SECTION: SHEET METALWORK, GENERAL, shall be embedded in bituminous cement and nailed on top of the envelope.

6.2.6 Each course of roofing felts, in addition to being mopped in hot bitumen, shall be lapped as specified in Table I. Base sheets shall be nailed in accordance with Table II. For roof slopes above 1/2-inch per foot, felts shall be nailed as specified in Table II or III.

6.2.7 Nails and fasteners for securing roofing shall be flush-driven through flat metal disks of not less than 1-inch diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 1-inch diameter disks.

6.2.8 At end of each day's work or whenever precipitation is imminent, the terminated edge of built-up roofing shall be sealed with two full-width strips of felt set in bituminous cement. [Cut insulation pieces shall be temporarily layed in place to straighten the exposed edge of insulation.] Extend half-width of strips up and over the [finished roofing] [insulation] and extend the other half-width out and onto the bare roof deck surface. [Water cutoffs

shall extend into and seal flutes in metal decks.] Water cutoffs [and temporary insulation pieces] shall be removed before continuing installation of roof system. [Extra full-width strips of felt shall be used as needed to insure complete covering of insulation.]

7. FLASHINGS: Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous plastic-type flashings described below shall be used, except where metal flashings are indicated or specified in SECTION: SHEET METALWORK, GENERAL. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends. Flashings shall be stepped where vertical surfaces abut sloped-roof surfaces.

7.1 Base Flashings: Materials and installation shall be in accordance with the approved recommendations of the roofing felt manufacturer. Base flashings shall consist of one ply of asbestos felt and one ply of a reinforced asbestos flashing sheet as the outer ply. Cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have a 5 1/2-inch face dimension and shall be continuous and installed in lengths as long as practicable. Cants are not required at locations where cast-in-place cants, specified under other sections, are integrally formed with the structural deck or roof fill. Cants shall be mitered at all changes of direction.

7.2 Strip Flashings: Roof flanges of lead and sheetmetal flashings, such as gravel stops, base flashings, and plumbing flashings, furnished and installed under other sections of the specifications, shall be stripped with two layers of roofing felt set in plastic cement. After installation of flanges of flashings over the top ply of roofing, the strip flashings, consisting of two layers of roofing felt, 9 and 12 inches wide, shall be successively cemented to the top of the roof flange using bituminous plastic cement to form a waterproof joint between roofing and flashings.

7.3 Valleys: Felt plies shall continue across valleys and terminate approximately 12 inches from the valley. Exposed lap shall terminate on a line approximately 12 inches from, and parallel to, the valley gutter. Two plies of felt, 9 and 12 inches wide, shall be successively mopped-in over each felt line of termination.

7.4 Sleeve-Type Bitumen Stops shall be installed at all pipe and conduit roof penetrations. Sleeve shall be ___ inches high; flange shall be 3 inches wide. Flange of bitumen stop shall be placed [on the deck below the vapor barrier] [on the insulation or underlayment below the roofing membrane.] Bitumen stops shall be made of copper and nailed in place as specified in SECTION: SHEET METALWORK, GENERAL. Pipes and conduits shall be flashed with lead or sheet metal flashings as specified in SECTION: SHEET METALWORK, GENERAL. (I)

7.5 Bitumen Pockets shall be installed on top of the roofing membrane at all irregularly shaped roof penetrations and at pipe and conduit penetrations which cannot be flashed with sleeve-type bitumen stops. Bitumen pocket shall be 3 inches high; flange shall be 4 inches wide. Flange shall be set in plastic cement and nailed as specified in SECTION: SHEET METALWORK, GENERAL.

Pocket shall be filled with 1 inch of plastic cement and 2 inches of bitumen. After bitumen has cooled, a tapered layer of plastic cement shall be applied and trowelled smooth.

8. [WOOD WALKWAYS: Walkways shall be supported on 2- by 6-inch wood bases cut in lengths not less than 4 inches wider than the span of the runners and set on premolded filler strips embedded in a uniform layer of bituminous cement. Premolded filler strips shall be at least 3/8 inch thick. Wood bases shall be spaced not more than 48 inches on center. Wood bases shall be made of pressure-preservative-treated materials as specified in SECTION: ROUGH CARPENTRY. Surfacing aggregate shall not be embedded in areas over which wood walkways are to be installed.] (G)

9. [COMPOSITION-TYPE TRAFFIC SURFACES: Mineral-surfaced asphalt plank treads shall be embedded in the flood coat prior to aggregate surfacing. Planks or treads shall be spaced 6 inches apart.] (G)

10. SURFACING: Contractor shall determine the moisture content of a representative sample of the surfacing material as determined by the Contracting Officer. If materials are found with excessive moisture contents, the materials shall be dried on the site to meet ASTM D 1863 specifications. After roofing felts have been laid and flashings installed, the roof surface, except for cants, shall be flood-coated uniformly with 60 pounds of asphalt per square. While bitumen is still hot, 400 pounds per square of roofing aggregate shall be embedded therein. Aggregate shall be placed in the manner and quantity required to form a compact embedded overlay. Roof surface shall be swept and all loose aggregate removed. Flood coat and aggregate shall be applied the same day as the felts are laid. If there is a probability of rain falling on the felts before the flood coat and aggregate can be applied, a light glaze coat of bitumen, 10 to 15 pounds per square, shall be applied over the exposed felts. The glaze coat may be considered as part of the flood coat provided the surfacing operation is completed within 48 hours after application of the glaze coat. Where glaze coat is used, surface treatment shall be completed as soon as weather conditions permit.

11. QUALITY ASSURANCE

11.1 Reverification of Temperature Controls: Contractor shall verify the accuracy of the temperature recorder each work day before using bitumen from kettle or tanker using a portable thermometer.

11.2 Charts and Records: Contractor shall provide daily the chart from the temperature recorder and evidence that the recorder accuracy was verified.

11.3 Application Temperatures: Contractor shall furnish a daily record indicating the application temperature of each bucket of bitumen accepted on the roof.

11.4 Roof Cutout Samples: Roof sampling shall comply with ASTM D 3617 except that one sample shall be taken for each 10 squares (1000 square feet) of roofing, and also as directed by the Contracting Officer when there is reason to believe that deficiencies exist. Sample dimensions shall be 4 inches by 36 inches. Length of sample shall be taken across the felts. The Government will test the sample for head laps, weight, free water, and existence of

voids. The hole in the roofing membrane shall be flooded with hot bitumen, and a new section of equivalent size and structure shall be built in the hole. The sample area shall be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the sample area 3 inches on all sides and each succeeding ply overlapping the preceding 3 inches on all sides. If the sample indicates a deficiency, the Contractor shall take additional samples to determine the extent of the deficiency. Deficient roofing shall be removed and replaced. A sample shall be taken from replaced roofing.

TABLE 1

LAPS FOR ROOFING FELTS AND ROLL ROOFING(a)

Layers or plies	Laps in inches for 36-inch width	Starting widths in inches for 36-inch width
1	4	36
3	24-2/3	12, 24 and 36
4	27-1/2	9, 18, 27, and 36

(a) End laps of roofing felts and roll roofing shall be not less than 6 inches and shall be staggered a minimum of 12 inches.

TABLE II

NAILING OF BUILT-UP ROOFING LAID DIRECTLY ON DECK(a),
FOR FELTS ON ROOF SLOPES ABOVE 1/2 INCH PER FOOT, AND
BASE SHEETS LAID ON ALL SLOPES WITHOUT MOPPING

Type of Deck	Base Sheet	Mopped Felts	Remarks
Gypsum and insulating concretes	Nail 6" on center, staggered in two rows 2" and 6" from lower edge.	Nail 12" on centers, staggered in two rows 2" and 6" from upper edge.	
Concrete		Nail each ply 2" and 6" from upper edge into nailers.	Precast decking provided with wood or nailable concrete inserts at 2'-0" on centers
Steel			Roofing not to be laid directly on steel decks.

(a) Includes the use of conventional nails or other approved fasteners.

TABLE III

NAILING OF BUILT-UP ROOFING LAID ON INSULATION
FOR ROOF SLOPES ABOVE 1/2 INCH PER FOOT

Expanded-Perlite, Fiberboard or Mineral-Fiber	Composite Board, Cellular Glass, Isocyanurate or Urethane
Nail 12" on centers into insulation staggered in two rows 2" and 6" from upper edge.	Nail into surface mounted roof nailing strips provided and installed in SECTION: INSULATION FOR BUILT-UP ROOFING. Nail each ply at 2", 5", and 8" from upper edge with nails penetrating at least 3/4" into nailing strips.

GENERAL NOTES

1. This guide specification is to be used in the preparation of contract specifications in accordance with ER 1110-345-720. It will not be made a part of a contract merely by reference; pertinent portions will be copied verbatim into the contract documents.
2. The capital letters in the right-hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specifications.
3. Where numbers, symbols, words, phrases, clauses, or sentences in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portions(s) carefully. Where blank spaces occur in sentences, insert the appropriate data. Where entire paragraphs are not applicable, they should be deleted completely.

TECHNICAL NOTES

- A. The section number will be inserted in the specification heading and prefixed to each page number in project specifications.
- B. This section, intended to cover built-up roofing on various types of roof decking and insulation, has been modified to include several unique requirements to support a research project investigating methods for improving the quality of such roofing systems. This section is not to be used for specifying roofing systems in the regular construction program.
- C. Paragraph 1: The listed designations for publications are those that were in effect when this guide specification was being prepared. To minimize the possibility of error, the letter suffixes, amendments, and dates indicating specific issues should be retained in paragraph 1 and omitted elsewhere in the project specifications.
- D. Paragraph 4.7: When it is locally available, light-colored aggregate will be specified.
- E. Paragraph 5: Mechanical fastening will be required for built-up roofing on slopes greater than 1/2 inch per foot.
- F. Paragraphs 5 and 6: Tables II and III: Inapplicable table reference will be deleted.
- G. Paragraphs 8 and 9: Walkways or traffic surfaces must be indicated on the drawings. Select either wood walkways or the composition-type traffic surface.

- H. Paragraph 4.9: Asphalt plank is available in thicknesses from 3/4 inch to 2 inches by 1/4-inch increments. Insert the desired thickness.
- I. Paragraph 7.4: Purpose of bitumen stop is to prevent hot bitumen from running down the pipe into the building. Pipe must still be covered with lead or sheet metal flashing after roof membrane is installed. Height of bitumen stop is 3 inches if installed under roof membrane. Extra height is needed if installed under vapor barrier to allow for thickness of insulation and roof membrane and still project at least 2" above roof.
- J. General: Roofing manufacturers and pertinent data published by Factory Mutual will be consulted for recommendations on mechanical fastening in areas where high winds have caused roof damage.

Wood nailers are specified in SECTION: INSULATION FOR BUILT-UP ROOFING and should be included in this section if roofing is installed without board-type insulation or underlayment.

In reroofing projects, designers should consider the use of fill material or tapered insulation to restore roof slope to ensure drainage.

Expansion joints in the roofing should be provided: (1) at each expansion joint in the structure, (2) uniformly spaced not over 200 feet apart in length or width of roof; and (3) at each intersection where an "L" or "T" shaped roof deck changes direction. Expansion joints should be located at high points, where practicable, and should be placed on curbs above the water line.

To the maximum extent possible, the relative position of insulation and roof deck components should be in accordance with TM 5-805-3.

Proper ventilation of lightweight structural concrete and lightweight insulating concrete is mandatory to assure drying of the deck.

*** E N D ***

BUILT-UP GLASS FIBER ROOFING

CERL ROOFING STUDY TEST GUIDE SPECIFICATION FOR
BUILT-UP GLASS FIBER ROOFING

(A) (B)

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. (C)

1.1 American Society for Testing and Materials (ASTM) publications:

C 208-72	Insulating Board (Cellulosic Fiber), Structural and Decorative.
D 41-73	Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
D 226-77	Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
D 250-77	Asphalt-Saturated Asbestos Felt Used in Roofing and Waterproofing.
D 312-71(R 1977)	Asphalt Used in Roofing.
D 517-70	Asphalt Plank.
D 1751-73	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
D 2178-76	Asphalt-Impregnated Glass Mat Used in Roofing and Waterproofing.
D 2822-75	Asphalt Roof Cement.
D 3617-77	Sampling and Analysis of New Built-Up Roof Membranes.

1.2 Federal Specifications (Fed Spec):

SS-R-630

Roofing Felt (Roll, Asphalt-
Prepared, Mineral Surfaced).

2. GENERAL: Asphalt bitumen glass-felt built-up roofing shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage of Materials: Roofing materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Felts and roll roofing shall not be exposed to any moisture before, during, or after delivery to the site. Felts and roll roofing shall be stored in an enclosed building or in a trailer, stacked on end, and maintained above 50 degrees F for 24 hours immediately before laying.

2.2 Coordination Requirements: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations the same day felts are installed. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is waterproofed the same day with the complete roofing system.

2.3 Preparation Requirements: The entire roof-deck construction of any bay or section of the building shall be completed before roofing work is begun thereon. Roofing on lightweight insulating concrete shall not be scheduled until the insulating concrete passes the air-dry density test specified therefor in SECTION: CONCRETE. Roofing on structural concrete or concrete fill shall not be scheduled until frothing or bubbling does not occur when hot bitumen is applied to the deck and until the hot bitumen sticks tightly to the deck. Items penetrating the roof shall be secured in position and properly prepared for flashing.

2.4 Preparation for Reroofing: Existing roof deck shall be stripped of roofing membrane, insulation, vapor barrier, cants, embedded flashing, nails, fasteners, and deteriorated nailers. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at end of each working day.

2.5 Application Requirements: Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. The roofing or

flashing shall be applied to a smooth and firm surface free from ice, frost, moisture, dirt, and foreign materials. Application of roofing shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40 degrees F.

2.6 Bituminous-plastic-type flashings installed in accordance with these specifications shall be used throughout unless otherwise specified or indicated. Metal flashings are specified in SECTION: SHEET METALWORK, GENERAL.

3. SUBMITTALS

3.1 Certificates of Compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the SPECIAL PROVISIONS.

3.2 Manufacturers Installation Instructions shall be submitted and approved prior to delivery of materials to the site. Instructions shall specify acceptable range of bitumen application temperatures. Bitumen manufacturer shall specify maximum temperature for holding bitumen in a heated condition.

3.3 Temperature Control Equipment. Contractor shall submit manufacturer's literature on the automatic temperature recorder and automatic thermostatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting that the recorder, automatic temperature control, and portable thermometer were each tested immediately prior to shipment to the site and that all operate within the accuracy tolerances given in the manufacturers specifications. Temperature control and recording equipment shall be in proper working condition during use.

3.4 Samples. The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

Felts - 7-ft sample from end of each roll used
Bitumen - 10 pounds of each type used
Primer - 1 gallon
Bituminous cement - 1 gallon
Surfacing materials - 100 pounds
Nails, fasteners, and anchors - 1 pound of each type, size, and style
Premolded filler strip - 1 strip 6 feet long
Asphalt plank - 1 square foot

4. MATERIALS:

4.1 Asphalt Primer: ASTM D 41.

4.2 Asphalt: ASTM D 312 as follows:

4.2.1 Type II or Type III on slopes above 1/2 inch per foot up to and including 1 inch per foot.

4.2.2 Type III on slopes above 1 inch per foot up to and including 3 inches per foot.

4.3 Cants shall be made from treated wood or treated fiberboard and shall reduce the angle covered into two equal angles. Treated wood shall be of water-borne preservative-treated material as specified in SECTION: ROUGH CARPENTRY. Fiberboard shall conform to ASTM C 208 treated for moisture resistance by integral treatment with wax or other sizing or with bituminous impregnation.

4.4 Felt shall be the asphalt saturated type and shall conform to the following requirements:

4.4.1 Organic Roofing Felt: ASTM D 226, Type I.

4.4.2 Asbestos Roofing Felt: ASTM D 250, Type I.

4.4.3 Glass Roofing Felt: ASTM D 2178, Type [III or IV] [IV]. (I)

4.4.4 Glass Base Sheet: ASTM D 2178, Type V.

4.4.5 Glass Roll Roofing: Fed Spec SS-R-630, Class 3, [with 4-inch] [without] selvage edge.

4.5 Nails, Fasteners, and Anchors shall be an approved type recommended by the roofing felt manufacturer. Fasteners for securing roofing felts to mineral-fiber, expanded perlite or fiberboard insulation, concrete, and gypsum surfaces shall provide a minimum holding power of 20 pounds each when installed.

4.6 Roofing Cement: ASTM D 2822, Type I.

4.7 Premolded Filler Strip: ASTM D 1751, minimum 3/8 inch thick.

4.8 Asphalt Plank: ASTM D 517, _____ inch thick, mineral surfaced. (G)

5. ASPHALT BUILT-UP 4-PLY ROOFING (D) (E)

5.1 On Precast-Gypsum, Cast-In-Place Gypsum, or Insulating Concrete Surfaces: One ply of glass base sheet lapped in accordance with Table I shall be laid, without mopping, at right angles to the direction of the roof slope and fastened in accordance with Table II. Two plies of glass roofing felt shall be immediately laid shingle-fashion in hot solid moppings of asphalt. Each ply shall be lapped as specified in Table I [and fastened in accordance with Table II]. One ply of mineral-surface roll roofing shall then be applied, without nailing. Roll roofing shall be cut and stacked when not machine applied. The flashings shall then be installed.

5.2 On Concrete or Insulation Surfaces: Three plies of glass roofing felt shall be mopped in solid with hot asphalt. Felts shall be laid shingle-fashion at right angles to the direction of the roof slope and lapped in accordance with Table I [and fastened in accordance with Table [II] [III]]. One ply of mineral-surfaced roll roofing shall then be applied, without nailing. Roll roofing shall be cut and stacked when not machine applied. The flashings shall then be installed.

6. APPLICATION OF ROOFING:

6.1 General Requirements: The entire roofing system shall be finished in one operation up to the line of termination at end of day's work. Application of roofing shall immediately follow application of insulation as a continuous operation. Phased construction will not be permitted. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen.

6.2 Detail Requirements:

6.2.1 [Prior to application of roofing, joints in precast concrete decks shall be covered with a 4-inch strip of roofing felt, embedded in and coated with bituminous cement. Concrete surfaces to receive asphalt products shall be primed at a rate of not less than 1 gallon per square. Bitumen shall uniformly cover all roof areas to be mopped to provide effective bond.]

6.2.2 Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

6.2.3 Bitumen stops formed of edge envelopes shall be installed at eaves and rakes. Only organic or asbestos felts shall be used. Envelopes shall be formed of two 18-inch wide layers of roofing felt. Nine inches of the width shall be attached to the roof surface with 9 inches extending beyond the edge. The first layer shall be applied in a 4-inch wide layer of roofing cement and nailed 1/2-inch from the roof edge at 6-inch spacing. The second layer shall be applied to the first in a 9-inch wide mopping of bitumen. The free edges shall be protected from damage throughout the roofing period.

6.2.4 Application and holding temperatures shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers. Each layer of roofing felt shall be laid in not less than 15 pounds of asphalt per square or more than 25 pounds of asphalt per square. Final layer of roll roofing shall be laid in not less than 20 nor more than 30 pounds of Type III asphalt per square.

6.2.5 Layers of roofing shall be laid free of wrinkles, creases or fishmouths, at right angles to the slope of the deck, immediately behind the applicator. The surface of the felts shall be broomed-in full width to obtain complete adhesion between plies and to eliminate air pockets. Brooms shall have soft bristles and shall be discarded when the bitumen build-up on the fiber prevents application of equal pressure across the broom width on felts. The method of mopping a half-sheet width and turning the sheet back to mop under the other half will not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 4 inches, or to the top of the cant strip. After the last ply of roofing felt is applied, the edge envelope shall be formed by folding back and mopping each layer. The gravel stop, specified in SECTION: SHEET METALWORK, GENERAL, shall be embedded in bituminous cement and nailed on top of the envelope.

6.2.6 Each course of roofing felts, in addition to being mopped in hot bitumen, shall be lapped as specified in Table I. Base sheets shall be nailed in accordance with Table II. For roof slopes above 1/2-inch per foot, felts shall be nailed as specified in Table II or III.

6.2.7 Nails and fasteners for securing roofing shall be flush-driven through flat metal disks of not less than 1-inch diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 1-inch diameter disks.

6.2.8 At end of each day's work or whenever precipitation is imminent, the terminated edge of built-up roofing shall be sealed with two full width strips of felt set in bituminous cement. [Cut insulation pieces shall be temporarily layed in place to straighten the exposed edge of insulation.] Extend half-width of strips up and over the [finished roofing] [insulation] and extend the other half-width out and onto the bare roof deck surface. [Water cutoffs shall extend into and seal flutes in metal decks.] Water cutoffs [and temporary insulation pieces] shall be removed before continuing installation of roof system. [Extra full-width strips of felt shall be used as needed to insure complete covering of insulation.]

7. FLASHINGS: Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous-plastic-type flashings described below shall be used, except where metal flashings are indicated or specified in SECTION: SHEET METALWORK, GENERAL. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends. Flashings shall be stepped where vertical surfaces abut sloped-roof surfaces.

7.1 Base Flashings: Materials and installation shall be in accordance with the approved recommendations of the roofing felt manufacturer. Base flashings shall consist of two plies of glass felt and one ply of mineral surfaced roll roofing as the outer ply. Cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base

flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have a 5 1/2-inch face dimension and shall be continuous and installed in lengths as long as practicable. Cants are not required at locations where cast-in-place cants, specified under other sections, are integrally formed with the structural deck or roof fill. Cants shall be mitered at all changes of direction.

7.2 Strip Flashings: Roof flanges of lead and sheetmetal flashings, such as gravel stops, base flashings, and plumbing flashings, furnished and installed under other sections of the specifications, shall be stripped with two layers of glass roofing felt set in plastic cement. After installation of flanges of flashings over the top ply of roofing, the strip flashings, consisting of two layers of roofing felt, 9 and 12 inches wide, shall be successively cemented to the top of the roof flange using bituminous plastic cement, to form a waterproof joint between roofing and flashings.

7.3 Valleys: Felt plies shall continue across valleys and terminate approximately 12 inches from the valley. Exposed lap shall terminate on a line approximately 12 inches from, and parallel to, the valley gutter. Two plies of glass felt, 9 and 12 inches wide, shall be successively mopped-in over each felt line of termination.

7.4 Sleeve-Type Bitumen Stops shall be installed at all pipe and conduit roof penetrations. Sleeve shall be 3 inches high; flange shall be 3 inches wide. Flange of bitumen stop shall be placed [on the deck below the vapor barrier] [on the insulation or underlayment below the roofing membrane.] Bitumen stops shall be made of copper and nailed in place as specified in SECTION: SHEET METALWORK, GENERAL.

7.5 Bitumen Pockets shall be installed on top of the roofing membrane at all irregularly shaped roof penetrations, and at pipe and conduit penetrations which cannot be flashed with sleeve-type bitumen stops. Bitumen pocket shall be 3 inches high; flange shall be 4 inches wide. Flange shall be set in plastic cement, and nailed as specified in SECTION: SHEET METALWORK, GENERAL. Pocket shall be filled with 1 inch of plastic cement and 2 inches of bitumen. After bitumen has cooled, a tapered layer of plastic cement shall be applied and trowelled smooth.

8. [WOOD WALKWAYS: Walkways shall be supported on 2- by 6-inch wood bases cut in lengths not less than 4 inches wider than the span of the runners and set on premolded filler strips embedded in a uniform layer of bituminous cement. Premolded filler strips shall be at least 3/8 inch thick. Wood bases shall be spaced not more than 48 inches on center. Wood bases shall be made of pressure-preservative-treated materials as specified in SECTION: ROUGH CARPENTRY.] (F)

9. [COMPOSITION-TYPE TRAFFIC SURFACES: Mineral-surfaced asphalt planks (F) or treads shall be embedded in a uniform layer of bituminous cement. Planks or treads shall be spaced 6 inches apart.]

10. QUALITY ASSURANCE

10.1 Reverification of Temperature Controls: Contractor shall verify the accuracy of the temperature recorder each work day before using bitumen from kettle or tanker using a portable thermometer.

10.2 Charts and Records. Contractor shall provide daily the chart from the temperature recorder and evidence that the recorder accuracy was verified.

10.3 Application Temperatures: Contractor shall furnish a daily record indicating the application temperature of each bucket of bitumen accepted on the roof.

10.4 Roof Cutout Samples: Roof sampling shall comply with ASTM D 3617 except that one sample shall be taken for each 10 squares (1000 square feet) of roofing, and also as directed by the Contracting Officer when there is reason to believe that deficiencies exist. Sample dimensions shall be 4 inches by 36 inches. Length of sample shall be taken across the felts. The Government will test the sample for head laps, weight, free water, and existence of voids. The hole in the roofing membrane shall be flooded with hot bitumen, and a new section of equivalent size and structure shall be built in the hole. The sample area shall be covered with 3 plies of glass felt, hot mopped in place with the first ply overlapping the sample area 3 inches on all sides and each succeeding ply overlapping the preceeding 3 inches on all sides. If the sample indicates a deficiency, the Contractor shall take additional samples to determine the extent of the deficiency. Deficient roofing shall be removed and replaced. A sample shall be taken from replaced roofing.

TABLE I
LAPS FOR ROOFING FELTS AND ROLL ROOFING(a)

Layers or plies	Laps in inches for 36-inch width	Starting widths in inches for 36-inch width
1	4	36
2	19	18 and 36
3	24-2/3	12, 24, and 36

(a) End laps of roofing felts and roll roofing shall be not less than 6 inches and shall be staggered a minimum of 12 inches.

TABLE II

NAILING OF BUILT-UP ROOFING LAID DIRECTLY ON DECK(a),
FOR FELTS ON ROOF SLOPES ABOVE 1/2 INCH PER FOOT, AND
BASE SHEETS LAID ON ALL SLOPES WITHOUT MOPPING

Type of Deck	Base Sheet	Mopped Felts	Remarks
Gypsum and insulating concretes	Nail 6" on center, staggered in two rows 2" and 6" from lower edge.	Nail 12" on centers, staggered in two rows 2" and 6" from upper edge.	
Concrete		Nail each ply 2" and 6" from upper edge into nailers.	Precast decking provided with wood or nailable concrete inserts at 2'-0" on centers
Steel			Roofing not to be laid directly on steel decks.

(a) Includes the use of conventional nails or other approved fasteners.

TABLE III

NAILING OF BUILT-UP ROOFING LAID ON INSULATION
FOR ROOF SLOPES ABOVE 1/2 INCH PER FOOT

Expanded-Perlite, Fiberboard or Mineral-Fiber	Composite Board, Cellular Glass, Isocyanurate or Urethane
Nail 12" on centers into insulation staggered in two rows 2" and 6" from upper edge.	Nail into surface mounted roof nailing strips provided and installed in SECTION: INSULATION FOR BUILT-UP ROOFING. Nail each ply at 2", 5", and 8" from upper edge with nails penetrating at least 3/4" into nailing strips.

GENERAL NOTES

1. This guide specification is to be used in the preparation of contract specifications in accordance with ER 1110-345-720. It will not be made a part of a contract merely by reference; pertinent portions will be copied verbatim into the contract documents.
2. The capital letters in the right hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specifications.
3. Where numbers, symbols, words, phrases, clauses, or sentences in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portions(s) carefully. Where blank spaces occur in sentences, insert the appropriate data. Where entire paragraphs are not applicable, they should be deleted completely.

TECHNICAL NOTES

- A. The section number will be inserted in the specification heading and prefixed to each page number in project specifications.
- B. This section, intended to cover built-up roofing on various types of roof decking and insulation, has been modified to include several unique requirements to support a research project investigating methods for improving the quality of such roofing systems. This section is not to be used for specifying roofing systems in the regular construction program.
- C. Paragraph 1: The listed designations for publications are those that were in effect when this guide specification was being prepared. To minimize the possibility of error, the letter suffixes, amendments, and dates indicating specific issues should be retained in paragraph 1 and omitted elsewhere in the project specifications.
- D. Paragraph 5: Mechanical fastening will be required for built-up roofing on slopes greater than 1/2 inch per foot.
- E. Paragraphs 5 and 6: Tables II and III: Inapplicable table references will be deleted.
- F. Paragraphs 8 and 9: Walkways or traffic surfaces must be indicated on the drawings. Select either wood walkways or the composition-type traffic surface.
- G. Paragraph 4.9: Asphalt plank is available in thicknesses from 3/4 inch to 2 inches by 1/4 inch increments. Insert the desired thickness.

- H. General: Roofing manufacturers and pertinent data published by Factory Mutual will be consulted for recommendations on mechanical fastening in areas where high winds have caused roof damage.

Wood nailers are specified in SECTION: INSULATION FOR BUILT-UP ROOFING and should be included in this section if roofing is installed without board-type insulation or underlayment.

In reroofing projects, designers should consider the use of fill material or tapered insulation to restore roof slope to ensure drainage.

Expansion joints in the roofing should be provided: (1) at each expansion joint in the structure, (2) uniformly spaced not over 200 feet apart in length or width of roof; and (3) at each intersection where an "L" or "T" shaped roof deck changes direction. Expansion joints should be located at high points, where practicable, and should be placed on curbs above the water line.

To the maximum extent possible, the relative position of insulation and roof deck components should be in accordance with TM 5-805-3.

Proper ventilation of lightweight structural concrete and lightweight insulating concrete is mandatory to assure drying of the deck.

- I. Paragraph 4.4.3: Type IV felt will be specified exclusively for all climates where the average January temperature is below 40 degrees F. For those climates where the average January temperature is above 40 degrees F, the option for Type III or Type IV felt will be retained.

*** E N D ***

ELASTOMERIC ROOFING, FLUID APPLIED

CERL ROOFING STUDY TEST GUIDE SPECIFICATIONS

FOR ELASTOMERIC ROOFING, FLUID APPLIED

(A) (B)

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. (C)

1.1 American Society for Testing and Materials (ASTM) Publications:

C 728-72	Perlite Thermal Insulation Board
D 312-78	Asphalt Used in Roofing
D 1521-73	Compressive Properties of Rigid Cellular Plastics
D 1622-63	Apparent Density of Rigid Cellular Plastics
D 2626-73	Asphalt-Saturated and Coated Organic Felt Base Sheet Used in Roofing
D 2822-75	Asphalt Roof Cement
E 96-66 (R1972)	Water Vapor Transmission of Materials in Sheet Form

1.2 Factory Mutual Corporation (FM) Publications:
Approval Guide, Equipment, Materials, Services for Conservation of Property.

[1.3 (Underwriters' Laboratories, Inc. (UL) Publications:

(M)

UL 790	Tests for Fire Resistance of Roof Covering Materials.]
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1.4 American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. (ASHRAE) Publication:

ASHRAE Handbook and Product Directory, Fundamentals (1977)

2. GENERAL: The roofing system shall consist of a layer of sprayed-in-place urethane foam roof insulation covered with a two-coat elastomeric coating. The system shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage: Materials shall be delivered to the job site in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials shall be stored in clean and dry areas.

2.2 Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations.

2.3 Preparation: Surfaces shall be dry and free of loose coatings or other contaminants. Workmen shall wear clean, soft-soled sneaker-type shoes. (D)

2.4 Preparation For Reroofing: (E)

2.4.1 Removal: Debris from existing roof shall be removed using a covered chute or other device to minimize spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made at contractor's expense. Ground around chute shall be cleaned immediately after completion of removal activities.

2.4.2 Cleaning: Prepared roof area shall be cleaned with compressed air using three passes, each at a right angle to the preceding one. Last pass shall be made immediately prior to application of new roofing system. Debris accumulated shall be dumped down the chute. Contractor shall prevent the loss of debris around the perimeter of the building.

2.4.3 Protection: The roof shall be completely weatherproofed at the end of each work day. Removal activities shall be limited to that area which can be reroofed during the same day.

2.4.4 [Stripping: Existing built-up roofing system shall be left in place. Surface shall be cleared of all loose gravel and other debris. Blisters shall be cut, laid flat, and re-adhered with bituminous cement. Surface shall be cleaned.] (F)

2.4.4 [Stripping: Contractor shall remove the existing roofing system, cants, and embedded flashing. Insulation shall be left in place and protected from physical damage. Wet insulation shall be removed from the indicated areas and replaced with the same type and size as that removed. Surface shall be cleaned.] (F)

2.4.4 [Stripping: Existing roof deck shall be stripped of roofing system, insulation, and cants. Surface shall be cleaned.] (F)

2.4.5 Priming. After cleaning, roof surfaces shall be primed at an application rate recommended by the roofing manufacturer. (G)

2.5 Overspraying. Contractor shall construct barriers or take other measures to prevent overspraying and shall be responsible for damages resulting from overspraying.

3. SUBMITTALS: The following shall be submitted in accordance with the SPECIAL PROVISIONS:

3.1 Certificates of Compliance attesting that the materials meet the specification requirements, and certificate from coating manufacturer certifying that coating and foam system being supplied has been tested and meets the requirements of UL 790. (M)

3.2 Qualifications of Installer: Certificate from the foam and coating manufacturers identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's Instructions for installation of the foam and coating roofing system.

3.4 Samples shall be submitted as follows for independent Government testing:

Each component of foam and protective coating	5 gallon container
Thermal insulation board	one full-size section
Granules	10 pounds
Primer	1 gallon
Sealant	1 cartridge
Foam with coating	6 samples (2 ft x 2 ft) ¹
Foam with coating and wearing course	2 samples (2 ft x 2 ft) ¹

4. MATERIALS:

4.1 Urethane Foam: Cured foam shall conform to the following properties:

PROPERTY	TEST METHOD	VALUE
Density, lb/ft ³ overall	ASTM D 1622	2.7 min., 3.5 max.
Compressive Strength, psi parallel to rise	ASTM D 1621	40.0 min.
Thermal Conductivity (K factor) Btu/hr/ft ² /°F/in	ASTM C 177	new 0.11 max. aged 0.15 max.

¹ Constructed as described in paragraph 7.1.

4.2 Protective Coating System shall be one of the following permeable types with a maximum perm rating of 3.5 when tested as specified in ASTM E 96, procedure B.

4.2.1 Silicone Weather Coating, manufactured by General Electric Company (medium gray base coat SCM 3308/501C and cement gray top coat SCM 3304/3307C).

4.2.2 Silicone 3-5000 Construction Coating manufactured by Dow Corning Company (light gray base coat and white top coat).

4.2.3 Catalyzed urethane, IRATHANE Weather/Flex manufactured by Irathane Systems (urethane base coat of IRATHANE 300 and a hypalon top coat of IRATHANE 157).

4.3 Granules: No. 11 screen size, ceramic coated, in colors provided by the manufacturer.

4.4 Roofing Felt: ASTM D 2626, Type I.

4.5 Primer and Sealer shall be of the type recommended by the coating manufacturer.

4.6 Asphalt: ASTM D 312, Type III.

4.7 Bituminous cement: ASTM D 2822, Type I.

4.8 Thermal Insulation Board: ASTM C 728.

5. INSTALLATION: Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

5.1 Thermal Barriers: Metal decking shall be covered with a nominal one-inch-thick perlite thermal barrier fastened in place with adhesives or mechanical devices for a class 1 system conforming to FM Approval Guide. Barrier shall be covered with one layer of roofing felt mopped in full width, using four inch side laps and six inch end laps. End laps shall be staggered at least 12 inches. Asphalt shall be applied at a rate of 23 pounds per square, and felts shall be broomed in full width. (H)

5.2 Urethane Foam shall be sprayed on the prepared deck to a minimum thickness of one inch except where variations are needed to ensure drainage. Foam shall be applied in 1/2 inch lifts. Time between lifts shall not exceed 4 hours. The finished surface shall be smooth and free of voids, crevices, and pinholes. Foam with surface condition known as "tree bark" or "popcorn" shall be removed and replaced at the contractor's expense. Foam shall be extended up walls and around roof projections to form cants and flashings that terminate at least 2 inches above finished roof surface. Foam shall be cured and free from water, dust, oils, and other material which would impair adhesion of coating. No foam shall be allowed to stand more than 24 hours without a base protective coating. Foam shall cure at least one hour before application of protective coating.

5.2.1 Thickness of foam insulation [shown on the drawings is not to scale; actual installed thickness] shall be such as to provide a coefficient of heat transmission or U-value, through the completed roof construction air-to-air, not in excess of _____ BTU per hour, per square foot, per degree F, temperature difference, when determined for winter conditions in accordance with recognized methods in ASHRAE Handbook of Fundamentals. Roof construction air-to-air may include finished ceilings provided unceilinged areas do not occur under the same roof area. Computations to determine minimum required thickness shall be approved before foam is installed.

5.3 Protective Coating: Coatings shall be applied and cured in accordance with manufacturer's instructions. Coating shall consist of a base coat and top coat. Base coats exposed for more than 24 hours shall be cleaned with a detergent solution, rinsed thoroughly, allowed to dry, and recovered with base coating.

5.3.1 Base Coat shall have a minimum dry film thickness of 10 mils for silicone, or 15 mils for Irathane. Coatings shall completely cover the foam and extend up vertical surfaces 2 inches beyond foam. Coating shall be dry and clean before application of top coat.

5.3.2 Top Coat shall be applied at right angles to the direction of the base coat application. Total dry film thickness shall be 20 mils minimum. Film thickness shall be verified by taking samples as specified below. Foam with "orange peel" or "coarse orange peel" surfaces shall have additional coating applied as required to obtain minimum dry film thickness. (I)

5.4 Flashing: Areas to be flashed shall be dry and free from all dust, dirt, tar, oils, and other debris. Metal surfaces shall also be free from all rust. Termination points requiring flashing shall be caulked with manufacturer's recommended sealant. Coating shall then be applied at a rate of 1 gallon per 100 square feet to an area a minimum of 4 inches on either side of the sealant. After flashing system has cured, two additional coats shall be applied to flashing areas during normal coating operations.

5.5 Wearing Course: Granules shall be applied within 5 minutes of top coat application, using pressure equipment, at a rate of 50 lbs per 100 square feet. Granules shall be applied in a minimum of two passes, with the second at right angles to the first. Finished granule system shall be uniform over entire surface with no apparent void areas. No traffic shall be allowed on finished area for 24 hours after granule application is completed. (J)

5.6 Service Walks: Service walks shall be applied after the 2-coat system has been completed and cured. Service walks shall consist of an additional layer of coating and granules. Base coat material shall be used for color contrast if directed by Contracting Officer. (K)

6. EQUIPMENT CALIBRATION: Spray equipment for two-component systems shall be calibrated each day at start of operations, each restart, if there is a change in fan pattern, change in pressure, slow curing areas are noticed, change in work area requiring a change in hose length or in working height, after changing or cleaning filter elements, after changing curing agents, after changing between protective coatings, and whenever directed by the

Contracting Officer. Calibration shall consist of demonstrating that the equipment is adjusted to deliver components in the proportion and at the rate specified in approved manufacturer's instructions. Calibration tests shall be accomplished on the roof adjacent to the area to be sprayed.

7. CONTROL SAMPLES: Immediately following satisfactory completion of each calibration procedure, the Contractor shall collect samples as specified below. The date, time of day, and material identification of each sample layer shall be clearly marked.

7.1 Foam: Contractor shall prepare wooden open-top boxes 24 inches square by depth of finished roof section. Boxes shall be filled in 1/2-inch lifts during actual roof foaming, each lift being collected at the same time it is applied to the roof, adjacent to the area being sprayed. (L)

7.2 Protective Coating: Samples shall be collected after each calibration and at least once per ten squares of application in a continuous operation. Contractor shall place two Government-furnished test plates in path of spray operations and adjacent to area being sprayed, and remove them after being sprayed. Wet thickness shall be determined from one plate; if deficient, the Contractor shall be directed to take corrective action. The 24-inch square foam samples shall be coated in the same manner.

7.3 Wearing Course: Two of the 24-inch square samples shall consist of the completed roof system including wearing course.

8. INSPECTION: Foam surface will be inspected for texture, blisters, non-adherence to substrate, and other defects before finish coating is applied. All pinholes shall be finished flush with sealant recommended by the coating manufacturer. Roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications.

GENERAL NOTES

1. This guide specification is to be used in the preparation of contract specifications in accordance with ER 1110-345-720. It will not be made a part of a contract merely by reference; pertinent portions will be copied verbatim into the contract documents.
2. The capital letters in the right-hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specifications.
3. Where numbers, symbols, words, phrases, clauses, sentences or paragraphs in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portion(s) carefully. Where blank spaces occur in sentences, insert the appropriate data. Where entire paragraphs are not applicable, they should be deleted completely.

TECHNICAL NOTES

- A. The section number will be inserted in the specification heading and prefixed to each page number in project specifications.
- B. This specification is intended to cover urethane roofing systems for application on structural concrete with a compressive strength of not less than 2500 psi, plywood or metal decks, or over existing built-up roofing. The roofing system shall not be applied when structural deck is of light-weight concrete.
- C. Paragraph 1: The listed designations for publications are those that were in effect when this guide specification was being prepared. To minimize the possibility of error, the letter suffixes, amendments, and dates indicating specific issues should be retained in paragraph 1 and omitted elsewhere in the project specifications.
- D. Paragraph 2.3: Paragraph is intended for use when applying roofing over a new roof deck. Delete paragraph 2.4 in its entirety.
- E. Paragraph 2.4: Paragraph is intended for use when reroofing existing roof decks. Delete paragraph 2.3 in its entirety.
- F. Paragraph 2.4.4: Paragraphs covering three levels of stripping have been provided. Delete inapplicable paragraphs.
- G. Paragraph 2.4.5: Paragraph should be retained only if substrate is concrete, gypsum concrete, or built-up roofing.
- H. Paragraph 5.1: Paragraph should be retained only if deck is metal.
- I. Paragraph 5.3.2: For information, Dow Corning recommends 15 mils; GE 20 mils, and Irathane 20 to 26 mils.
- J. Paragraph 5.5: Designer's option.

- K. Paragraph 5.6: Designer's option. Usually required on roofs with predicted foot traffic related to maintenance or to provide access to a service area.
- L. Paragraph 7.1: Number and sizes of samples should be modified to secure samples needed to satisfy independent testing program.
- M. Paragraphs 1.3 and 3.1: Requirement for certification of testing under UL 790 shall be in compliance with Chapter 12 of DOD 4270.1-M, Construction Criteria Manual.

END

ELASTOMERIC SHEET ROOFING (EPDM)

CERL ROOFING STUDY TEST GUIDE SPECIFICATIONS
FOR ELASTOMERIC SHEET ROOFING (EPDM)

(A) (B)

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of (C)
this specification to the extent referenced. The publications are
referred to in the text by the basic designation only.

1.1 American Society for Testing and Materials (ASTM) Publications:

- | | |
|-----------|-----------------------------------------------------------------------|
| D 692-71 | Coarse Aggregate for Bituminous Paving Mixtures. |
| D 3253-77 | Vulcanized Rubber Sheetting for Pond,
Canal and Reservoir Linings. |

2. GENERAL: [Loose-laid with ballast] [Bonded] Ethylene Propylene Diene Monomer (EPDM) roofing shall be applied to the roof surfaces indicated. Roofing membrane shall be furnished in the largest sheets possible to minimize joints. All materials used for the roofing system shall be the products of a single manufacturer. Membrane shall be free of any pinholes, lumps and foreign material.

2.1 Standard Product: The EPDM roofing system, including flashing, shall be the standard product of a single manufacturer regularly engaged in the production of this type of product.

2.2 Delivery and Storage: Materials shall be delivered to the job site in the manufacturer's original, unopened packages, clearly marked with the manufacturer's name, brand name, and description of content. Materials shall be stored in clean, dry areas at a temperature between 60 degrees F and 80 degrees F.

2.3 Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is weatherproofed the same day with the completed roofing system.

2.4 Preparation Requirements: The entire roof-deck construction of any bay or section of the building shall be completed before roofing is begun. (D)
Roofing on lightweight insulating concrete shall not be scheduled until the concrete passes the air-dry density test specified in SECTION: CONCRETE. Roofing on structural concrete or concrete fill may be applied in lieu of curing compounds/membranes specified in SECTION: CONCRETE, or scheduled any time after the start of the curing period. Surfaces on or against which membrane is applied shall be smooth and dry, swept clean, and shall be free from oil, grease, sharp edges, and construction debris. Roofing shall not be applied in the rain or under excessive wind.

2.5 [Preparation for Reroofing: Existing roof deck shall be stripped of roofing system, insulation, and cants. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at end of each working day.] (E)

2.5 [Preparation for Reroofing: Existing roof surface shall be cleared of all loose stone, debris, oil, grease, and other objects that may damage the new roofing membrane.] (E)

3. SUBMITTALS: Contractor shall submit the following in accordance with the SPECIAL PROVISIONS:

3.1 Certificates of Compliance attesting that the materials meet specification requirements.

3.2 Qualifications of Installer: Certificate from manufacturer identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's Instructions for installation of the membrane, including procedures for preparing the membrane for use, flashing, splicing, [and bonding of the membrane] [use of prefabricated pipe sleeves for smoke testing, and smoke testing procedure].

3.4 Samples of Membrane Materials and Aggregate shall be submitted for testing by the Government. A 1-ft wide, full width sample shall be furnished from the end of each piece of EPDM membrane placed on the roof. In addition, 200 square feet of representative samples of the EPDM membrane used shall be furnished. An 18-inch long by 12-inch wide sample of the seam formed by connecting adjacent sheets of EPDM membrane shall be furnished from the first 100 feet of seam constructed plus an additional sample the same size from each additional 300 feet of seam constructed. In addition, 20 feet of seam 1-ft wide formed by connecting two sheets of EPDM shall be furnished. One quart of each bonding adhesive, one cartridge of sealant, 100 lbs. of ballast, and 1 lb. of fasteners shall also be furnished.

3.5 Shop Drawings showing the size of sheets, position of sheets and splices, flashing details, and nailing of sheets.

4. MATERIALS

4.1 Membrane shall be _____ inch thick, and shall comply with ASTM D 3253, Type II, except as follows: (F)

PROPERTY	VALUE
Tensile Strength	1400 psi min
Tear Resistance	125 lb/in min
Heat Aging (Accelerated) Elongation	210% min
Brittleness	-50°F min
Ozone Resistance	No Cracks
Permeability, Water Vapor	2.0 perm-mils

4.2 Adhesives: Cements and sealants shall be of types recommended by the roofing membrane manufacturer.

4.3 Wood nailers shall be number 2 or better grade lumber and shall be water-borne preservative treated.

4.4 Insulation shall be Urethane or Cellular Glass board insulation as specified in SECTION: INSULATION FOR BUILT-UP ROOFING.

4.5 Fasteners: Nails and fasteners used with flashing, nailers, and insulation shall be of the types and sizes best suited for the job and shall comply with roofing manufacturer's approved instructions.

4.6 Ballast shall be smooth, water-washed round stone approximately 3/4 to 1-1/2 inch diameter with gradation complying with ASTM D 692, Size 4.

4.7 Flashing shall be of durable elastomeric material compatible with the membrane specified, as furnished by the roofing manufacturer.

4.8 Prefabricated Accessories such as pipe seals and walkboards shall be of types and sizes recommended by the roofing membrane manufacturer.

5. INSTALLATION. Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

5.1 Nailers shall be installed on the perimeter of roof surfaces, curb flashing, skylights, expansion joints and similar penetrations, [and to divide the roof into segments not exceeding 1600 square feet each.] (G)

5.2 Insulation shall be placed completely covering the roof. Insulation shall be [loose-laid] [mechanically fastened] [fastened with hot asphalt] in accordance with SECTION: INSULATION FOR BUILT-UP ROOFING. [Mechanical] (H)

fasteners used to hold insulation in place shall be covered with 30 pound roofing felt adhered in place.] [Insulation around drains shall be tapered to provide a smooth transition between roof surface and drain clamping ring.]

5.3 Membrane shall be [fastened in place and] sealed to adjoining sheets using minimum 3 inch wide laps. Direction of lap shall be such that water flows over lap. Wrinkles shall not extend into terminations or field splices. Membrane shall be sealed to drain bases. [Nails fastening membrane to nailers forming the 1600 square feet grid shall be covered with 6 inch wide strips of sheeting.] [Prefabricated pipe sleeves for smoke testing shall be installed where indicated.]

5.4 Splices: Mating surfaces shall be cleaned with heptane, or with unleaded or white gasoline. Splice edges shall be cleaned of adhesive with solvents and sealed.

5.5 Perimeter Nailing: Membrane shall be mechanically fastened to all nailers using roofing nails. When using a vertical nailer, the nailer shall be installed over the membrane flush with the roof surface, securing the membrane at the horizontal plane.

5.6 Flashing: All projections and changes in roof planes shall be flashed. The splice between the flashing and the main roof sheet shall be completed before bonding the flashing to the vertical surface. The splice shall be sealed a minimum of 3 inches beyond the fasteners which attach the membrane to the horizontal nailer. The installed flashing shall be nailed at the top of the flashing a maximum of 12 inches on center under the metal counter-flashing or cap. Factory prefabricated pipe seals shall be used to flash all pipe where installation is possible.

5.7 Ballast shall be applied in a minimum 10 pounds per square foot layer over completed membrane. Membrane shall be protected from mechanical damage during ballast application. Ballast shall not be stockpiled on roof deck.] (I)

5.8 Cut-Offs: If work is terminated prior to weatherproofing the roof, the insulation line shall be straightened using loose-laid cut sheets and the membrane shall be sealed to the roof deck. Flutes in metal decking shall be sealed off along the cut-off edge. Membrane shall be pulled free or cut to expose the insulation when resuming work and cut insulation sheets used for fill-in shall be removed.

6.0 INSPECTION: All joints shall be inspected over entire length after completion and all defective areas resealed [before ballast is installed]. Damaged areas of membrane shall be removed and recovered, lapping underlying membrane by at least 3 inches on all sides. The roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications. Contractor shall submit the certificate to the Contracting Officer. [Contractor shall conduct smoke tests in compliance with manufacturer's approved instructions before ballast is installed. Leaks shall be repaired at the contractor's expense.]

GENERAL NOTES

1. This guide specification is to be used in the preparation of contract specifications in accordance with ER 1110-345-720. It will not be made a part of a contract merely by reference; pertinent portions will be copied verbatim into the contract documents.
2. The capital letters in the right-hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specifications.
3. Where numbers, symbols, words, phrases, clauses, sentences or paragraphs in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portion(s) carefully. Where blank spaces occur in sentences, insert the appropriate data. Where entire paragraphs are not applicable, they should be deleted completely.

TECHNICAL NOTES

- A. The section number will be inserted in the specification heading and prefixed to each page number in project specifications.
- B. This specification is intended to cover Ethylene Propylene Diene Monomer (EPDM) Elastomeric sheet roofing in loose-laid and bonded systems. This roofing system should not be used in areas exposed to waste products such as petroleum, grease, oil, and solvents; vegetable or mineral oil and animal fat; steam venting. EPDM can be laid three ways based on designer's selection: (1) loose laid membrane anchored on perimeter to nailers and sealed around penetrations. Insulation can be loose, mechanically fastened, or adhered in place with steep asphalt, (2) membrane bonded to insulation which is mechanically fastened to roof deck, (3) on concrete decks the membrane can be bonded to insulation laid on the roof subdivided into 1600 SF areas with nailers when the insulation is adhered to roof with steep asphalt. Loose laid EPDM can be applied to roofs having a maximum slope of 2 in 12. If project covers reroofing over existing built-up roofing, require that the roof surface be subdivided with wood nailers to form areas not more than 1600 SF and that new insulation be required to separate the membrane from existing roofing.
- C. Paragraph 1: The listed designations for publications are those that were in effect when this guide specification was being prepared. To minimize the possibility of error, the letter suffixes, amendments, and dates indicating specific issues should be retained in paragraph 1 and omitted elsewhere in the project specifications.
- D. Paragraph 2.4: Delete this paragraph if reroofing work is to be performed.
- E. Paragraph 2.5: Delete inapplicable paragraph. EPDM Roofing may be placed over existing built-up roofing, rather than requiring that the existing roofing be stripped prior to reroofing at the designer's option. Delete both paragraphs for new construction.

- F. Paragraph 4.1: Membrane for adhered system shall be .060" thick. Membrane for non-adhered (loose-laid) system shall be .045" thick.
- G. Paragraph 5.1: Nailers to divide the roof into areas of 1600 sq ft maximum shall be used only where insulation is not mechanically fastened to the deck, but is laid in hot asphalt. Also see Note B.
- H. Paragraph 5.2: Insulation must be 100% mechanically fastened to steel, gypsum, or insulating concrete roof deck. Insulation may be mechanically fastened to structural concrete deck or may be laid in hot steep asphalt. Mechanical fasteners must be covered only for loose-laid system.
- I. Paragraph 5.7: Delete this paragraph if roof membrane is bonded to substrate.

END

APPENDIX B
CONTRACT SPECIFICATIONS

FORT LEWIS, WASHINGTON

SPEC. NO. 3529 R1
(August 1979)

DEPARTMENT OF THE ARMY
HEADQUARTERS, 9TH INFANTRY DIVISION AND FORT LEWIS
Fort Lewis, Washington 98433

S P E C I F I C A T I O N S

For

Experimental Reroofing of Post Stockade
Building No. 1450
Fort Lewis, Washington

Directorate of Facilities Engineering
Fort Lewis, Washington

PART I - STATEMENT OF WORK

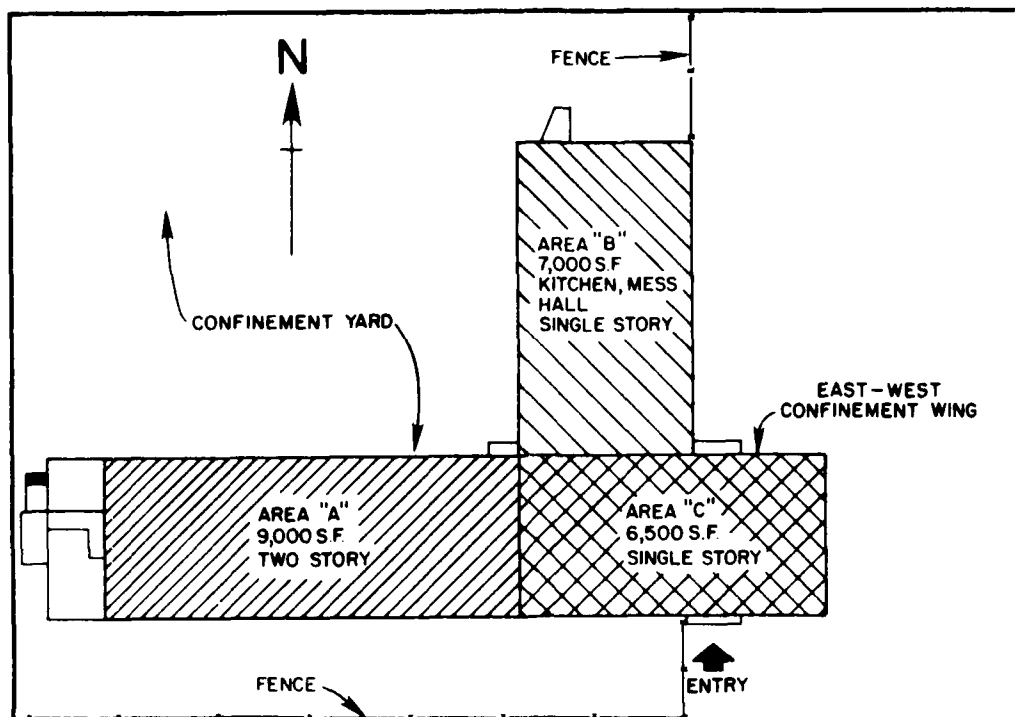
SECTION 1 - DESCRIPTION OF EXISTING ROOF SYSTEMS
(Refer to roof plan sketch on following Page SW-1-2)

This is the original roof of the Stockade Building which is about 23 years old. In recent years it has required excessive maintenance. Existing roofing of Post Stockade (Building 1450) is as shown on Drawings 27-07-04, Sheets No. 2 and 4 of 31 except asphaltic concrete saddles over areas "A" and "B" were not installed. Instead, "crickets" and "saddles" were apparently screeded into the structural concrete roof slabs in these areas.

Areas "A" and "B" roofing consists of built-up roofing with gravel surface over two courses of 1-1/4" thick wood fiber board insulation set in an asphalt floodcoat on the sloping concrete roof deck. Eave conditions consist of a continuous 2x6 coping block and aluminum gravel stop at all four sides of Area "A" and three sides of Area "B"; the fourth side of Area "B" consists of a copper sheet metal bellows type earthquake joint set on continuous wood coping blocks. Insulation in Areas "A" and "B" varies from damp to saturated with moisture.

Area "C" consists of gravel surface over built-up roofing over 1" to 9" thickness of light weight concrete over 2-1/2" wood fiber board insulation (two courses at 1-1/4") all over asphalt flood coat on dead flat concrete roof deck. The insulation in Area "C" varies from damp to saturated with moisture. Eave conditions consist of aluminum gravel stop on continuous wood coping block. One end of the roof is aluminum reglet flashed and counter-flashed to a masonry wall for the two story portion of the structure. A part of one side mates to the copper bellows earthquake joint between Areas "B" and "C".

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ROOF PLAN
NO SCALE
POST STOCKADE - BLDG. 1450

DIRECTORATE OF FACILITIES ENGINEERING Fort Lewis, Washington			
Date	Scale	Spec.	
10 JULY 79	AS NOTED	3529	
Symbol		Revision	Date

SW-1-2

PART I - STATEMENT OF WORK

SECTION 2 - DESCRIPTION OF WORK

1. DESCRIPTION OF WORK. - Provide all plant, labor, tools, equipment, materials, and perform all work in strict accordance with the specifications for Reroofing the Stockade Building No. 1450 at Fort Lewis, Washington. The new roof shall consist of three separate experimental roof systems as follows:

Area "A" - Single Ply Elastomeric Roofing

Area "B" - Elastomeric Roofing over sprayed Urethane Foam

Area "C" - Conventional Built-Up Roofing.

1.1 The principal items of work to be accomplished for each of the roof systems are. -

1.1.1 Area "A" (2d story roof about 9,000 square feet). -

1.1.1.1 Remove existing roofing, flashing, gravel stops, and insulation to concrete roof deck. Unfasten and remove existing aluminum eave gravel stop flashing to permit re-roofing and reuse of existing gravel stop. Inspect exposed 3 x 6 eavecoping blocks for soundness.

1.1.1.2 Prime concrete roof deck and install new vapor barrier.

1.1.1.3 Install 2-1/2 inch thick rigid insulation board with minimum thermal "R" value of 19. The 2-1/2 inch thickness is to be made up of two courses of rigid insulation board.

1.1.1.4 Install single ply elastomeric roofing and appropriate flashing at roof penetrations and at eaves.

1.1.1.5 Reinstall eave gravel stop flashing and seal.

1.1.1.6 Flash and caulk roofing at roof penetrations.

1.1.2 Area "B" (roof over kitchen/mess hall area, about 7,000 square feet).

1.1.2.1 Remove existing roofing, flashing and insulation down to concrete roof slab. Preserve existing gravel stop aluminum flashing (3 sides) and copper earthquake bellows flashing for reuse. Inspect existing wood eavecoping block for acceptability for reuse.

1.1.2.2 Replace existing untreated wood blocking supporting mechanical equipment with treated wood blocks.

1.1.2.3 Prime concrete roof deck and install vapor barrier.

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1.1.2.4 Prime concrete deck surface and spray or foam in place urethane foam to a thickness adequate to provide a thermal insulation resistance of R-19.

1.1.2.5 Re-install eave gravel stop flashing, earthquake joint flashing and flashing at roof penetrations and mechanical equipment.

1.1.2.6 Apply silicone coating(s) over the urethane foam.

1.1.2.7 Apply surfacing granules per manufacturer's recommendations (colors to be designated by Contracting Officer).

1.1.3 Area "C" (about 6,500 square feet, single story portion of east west detention wing). -

1.1.3.1 Remove existing built-up roofing and gravel, remove and salvage eave gravel stop aluminum flashing and earthquake copper bellows flashing to allow reroofing and re-use of the flashing. Remove reglet flashing and counter-flashing at wall along 2d story portion of the building. Inspect all treated wood eavecoping blocking for acceptability for reuse.

1.1.3.2 Remove "light-weight concrete" and the two layers of rigid insulation board below the concrete fill. (Note: The light-weight concrete varies in thickness from 1" to 9").

1.1.3.3 Provide special sealing and waterproofing at transverse construction joint across roof deck.

1.1.3.4 Prime concrete and install vapor barrier over concrete roof slab.

1.1.3.5 Install thermal setting insulating fill (light-weight asphaltic concrete) over vapor barrier on the roof deck.

1.1.3.6 Install two courses of 3/4" thick rigid insulating board over the insulating fill; hot asphalt mopping to insulating fill and to the previously laid rigid insulating board.

1.1.3.7 Provide new aluminum reglet flashing (.032" thick) and counter flashing (.032" thick) to a height of at least 12" above roof at wall of two story part of the building. (New reglet grooving required)

1.1.3.8 Apply new four-ply built-up roof with mineral surface cap sheet making and sealing to new and existing flashing sheet metal work at eaves, wall and earthquake copper bellow joint.

2. ACCESS TO AREAS FOR REROOFING. - Access to perform the reroofing shall be limited to the unfenced east side of roof Area "B" and north, east and south sides of roof Area "C". The reroofing shall not interfere with Stockade operations.

3. INTERFACE WITH OTHERS. - Government use of the facility in this project is anticipated while the work under this contract is being performed.

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The work shall be planned and accomplished so there will be a minimum of interference and inconvenience to occupants and agencies in the vicinity and to other persons who may have to work in this facility.

4. SPECIAL TESTING INSTRUMENTATION. - During construction of the three experimental roofing systems, special thermo couple instruments are to be installed by others on the bare roof decks for the purpose of future monitoring of temperature under the roofing. Contractor shall cooperate and assist in coordination of this effort.

5. SPECIAL QUALITY MONITORING. - Due to the experimental nature of this reroofing project, special Quality Control Inspection, monitoring and sampling will be exercised by Fort Lewis Facilities Engineering (DFAE), in cooperation with representatives of the Corps of Engineers Construction Engineering Research Laboratory (CERL). The Contracting Officer will designate a representative from DFAE, Fort Lewis, to act as the point of contact in coordinating the Special Quality Monitoring.

6. DRAWINGS. - The following drawings are pertinent to this project and are incorporated herein by reference:

<u>TITLE</u>	<u>DRAWING FILE NO.</u>	<u>DATE AND/OR LATEST REVISION DATE</u>
Fort Lewis Post Stockade (As-built)	27-07-04 Sheets 2 of 31 4 of 31	1 March 1955 28 March 1955

SW-2-3

PART II - TECHNICAL PROVISIONS

SECTION 1A - GENERAL

1. SCOPE. - This section covers general requirements applicable to all the Technical Provisions.

2. CERTIFICATES, SAMPLES, AND APPROVAL LISTS. -

2.1 General. -

2.1.1 Where required by other Sections of this contract, certification, samples, and approval lists shall be submitted at one time; no partial submission will be accepted except in unusual circumstances and then the submittal shall list the specific omissions or the Section of the Technical Provisions for which submittals have yet to be made.

2.1.2 All submittals shall be forwarded to the Contracting Officer for approval prior to commencement of work, or as otherwise called for in these specifications. Submittals shall have a cover letter, original, and four copies, which shall include the following information: (1) Date, (2) Contract Number, (3) This Specification Number, (4) Contractor's Name and Signature, (5) Manufacturer's Name and Identification Number of items for which submittal is made, (6) Page and Paragraph Number of these Technical Provisions which define the item.

2.1.3 Approval of the materials will be based on manufacturer's published ratings. Approval of materials, fixtures, and equipment under this provision shall not be construed as authorizing any deviations from the specifications unless the attention of the Contracting Officer has been directed to the specific deviations. Items differing from that specified may be proposed, provided the contractor clearly states such differences and provided all essential requirements of the specification are met. If the items offered under this provision are in the opinion of the Contracting Officer, equal to or better than that specified it will be given consideration.

2.2 Certification. - Authenticated certification of materials shall be submitted in quintuplicate. The certificate shall be either a brochure printed by the manufacturer or a notarized statement by an authorized representative of the manufacturer. In any case, the certificate shall clearly state compliance with the requirements of this specification.

2.3 Samples. - Samples shall be listed as required in paragraph 2.1.2 above. Unless otherwise requested one sample of each item called for shall be submitted. When required, samples of material shall be taken in the presence of a Contracting Officer's representative and shall be obtained by random selection from stock to be used on the job. Samples shall be clearly identified by designated name, specification number, batch number, where appropriate, project contract number, intended use where specific use not obvious.

2.3.1 Testing. - Unless otherwise noted, testing of original samples shall be the responsibility of the Government except that a retest which

was necessary because the original sample was defective shall be paid for by the contractor. At any time after the testing of original samples and samples tested as a result of failure of the original samples, other additional tests which the Contracting Officer may deem necessary will be paid for by the contractor when the samples tested do not meet applicable specifications. Whenever any portion of the contract states what the cost of retesting per sample of any item will be, that will be the cost charged the contractor for additional testing of that item when the liability for the cost of the testing arose pursuant to the preceding sentence. Installed material found defective shall be removed in its entirety and replaced at the contractor's expense.

2.4 Approval List of Materials, Fixtures, and Equipment called for in other Sections of these Technical Provisions shall be submitted in quintuplicate and as soon as practicable before any materials, fixtures, or equipment are purchased. This list of materials, fixtures, and equipment to be incorporated in the work, together with the names and addresses of the manufacturers and their catalog item numbers and trade names shall include catalogs, cuts, diagrams, drawings, and such other descriptive data as may be required by the Contracting Officer.

3. COORDINATION AND ACCESS TO SITE. -

3.1 Coordination with using agencies shall be made through the Contracting Officer's representative to assist the contractor in completing his work with a minimum of interference and inconvenience to occupants in the vicinity and other craftsmen working on the site.

3.2 When keys are required for access to facilities on this contract, they will be obtained through the Facilities Engineer Inspection Office.

3.2.1 The contractor shall be responsible for any Government-owned keys which have been issued to him for access to facilities or areas pertinent to this contract.

3.2.2 Upon completion of the work in an area, or upon request of the Contracting Officer, the key or keys relevant to the completed area shall be returned.

3.2.3 Should the contractor lose a key. -

3.2.3.1 He shall notify the Contracting Officer, in writing, within three (3) working days after he is aware of the loss.

3.2.3.2 Should the key not be found before final acceptance the final contract payment shall be reduced by \$10.00 for each key not returned.

4. REFUSE DISPOSAL AND CLEANUP. -

4.1 Refuse Disposal. - The costs of refuse disposal such as transportation, handling, and dumping fees is applicable, and similar costs shall be included in the appropriate bid item when applicable. Unless specifically indicated otherwise in other portions of the contract, any refuse generated

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as a result of this contract shall be disposed of in accordance with the following sub-paragraphs.

4.1.1 At Fort Lewis Only refuse (except fuel waste and sludge) may be disposed of in the Fort Lewis Sanitary Fill without charge. Entrance to the Sanitary Fill shall be coordinated with the Contracting Officer or his designated representative. For information, the Fort Lewis Sanitary Fill will be open on weekdays except for holidays between 7:30 A.M. and 3:30 P.M. only. Truck drivers going to the Sanitary Fill should know the contract number and the building from which the refuse was taken.

4.2 Fire Hazard. - Cloths and cotton waste that might constitute a fire hazard shall be placed in closed metal containers and placed outside or destroyed at the end of each day.

4.3 Restrictions. -

4.3.1 Refuse shall not be deposited in existing garbage cans or refuse dumpsters. Paint, varnish, oil, turpentine, thinner, fuel waste and sludge, etc., shall not be poured, drained, or washed into plumbing fixtures, sanitary or storm sewers, ditches, streams, or any other waterway; sprayed into the atmosphere as an aerosol or fine mist; or spread on the ground, paved areas, wooded areas, lawns or other areas at the post (except as specifically directed by the Contracting Officer). Open area burning and/or use of fuel waste products as a fuel in heating systems will not be permitted. All debris, dirt, dust and stains attributable to or resulting from the work effort shall be removed, cleaned or effaced to the satisfaction of the Contracting Officer prior to acceptance of the job.

SECTION 1B - QUALITY CONTROL

1. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designations only, form a part of this specification to the extent indicated by the references thereto:

1.1 Military Specifications. -

MIL-I-45208A Inspection System Requirements

MIL-Q-9858A Quality Program Requirements

2. The inspection system shall be in accordance with MIL-I-45208 and MIL-Q-9858.

2.1 In general MIL-I-45208 requires Contractor to inspect purchases for conformance to contract requirements.

2.2 In general MIL-Q-9858 requires an inspection system for total conformance to contract requirements.

3. Contractor's inspection system shall provide and maintain an effective method to assure that:

3.1 All supplies and services required under the contract, whether constructed or processed by the contractor, subcontractors or vendors, conform to contract requirements.

3.2 The latest available applicable drawings, including shop drawings, specifications, and instructions required by the contract, as well as authorized changes thereto, are used for fabrication, installation, inspection and testing.

3.2.1 Except for updating drawings furnished by the Government and work on shop drawings when required, the making of drawings of existing conditions is not a part of the Quality Control requirement. However, a sketch may be submitted with the Contractor Daily Inspection Form (HFL Form 1235) at the option of the contractor.

3.3 All measuring and testing devices, laboratory equipment, instruments, transportation, and supplies necessary to accomplish the required testing and inspection are provided, maintained and calibrated at established intervals against certified standards which have known valid relationships to national standards. The Contractor's measuring and testing equipment shall be made available for use by the Government for verification of their accuracy and condition as well as for any inspection or test desired.

3.4 Uncorrected defects are not built upon or concealed.

3.5 His field inspection system includes the requirement that:

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3.5.1 A preparatory inspection is performed prior to beginning any work on any definable feature. It should include a review of contract requirements; a check to assure that all materials and/or equipment have been tested, submitted, and approved; a check to assure that provisions have been made to provide required control testing; examination of the work area to ascertain that all preliminary work has been completed; and a physical examination of materials and equipment to assure that they conform to approved shop drawings or submittal data and that all necessary materials and/or equipment are on hand.

3.5.2 An initial inspection is performed as soon as work begins on a representative portion of the particular feature of work and should include examination of the quality of workmanship as well as a review of control testing for compliance with contract requirements.

3.5.3 The follow-up inspections are performed daily to assure continuing compliance with contract requirements.

3.6 Reports of all tests and inspections are made daily on a form similar to Headquarters Fort Lewis Form 1235 "Construction Inspection Report". Copies of this form may be obtained from the Contracting Officer's Office. This report:

3.6.1 Shall include record of Contractor's compliance with the Quality Control requirements noted elsewhere in the contract.

3.6.2 Must cover both conforming and defective items and all work placement subsequent to the previous report.

3.6.3 Shall include results of all tests and inspections, nature of defects, causes for rejection AND either the corrective action taken or proposed remedial action.

3.6.4 Shall have Contractor's blocks completely filled in and shall be given to the Contracting Officer's representative daily prior to noon on the next working day after that being reported on or as noted on the form.

3.7 Coordination needed with occupants is reported in appropriate block on Daily Contract Inspection Report and the requested times and dates are met.

SECTION 2 - DESCRIPTION OF NEW EXPERIMENTAL ROOF SYSTEMS

1. EXPERIMENTAL ROOFING SYSTEMS for reroofing areas "A", "B" and "C" of the Post Stockade (Building No. 1450) shall be as follows:

1.1 Area "A". - 9,000 square feet (approximately) roof over two story part at the westerly end of the east-west confinement wing. The new roofing system shall consist of the following:

1.1.1 Vapor Barrier. - The vapor barrier is to be applied directly to the primed concrete roof deck after priming the concrete surfaces. It shall consist of an asphalt saturated and coated inorganic felt; coated base sheet (No. 43) type I (plain) per A.S.T.M. Specification D-2626. The vapor barrier sheet shall be uniformly mopped to the deck with hot asphalt at 25 pounds per square and then top coated with an additional mopping of hot asphalt at the same rate (Refer to TECHNICAL PROVISIONS, Section 7).

1.1.2 Insulation. - The insulation shall be two and one half inches (2-1/2") thick with a minimum thermal insulating value of R-19. Insulation shall be rigid board stock of inorganic closed cell material. The insulation shall conform to the requirements of Technical Provisions, Section 6. The insulation boards shall be set in a 25 pound per square flood coat hot mopping of asphalt applied directly on the primed vapor barrier and between the courses of insulation board. The insulating board and its bonding agents shall be approved for compatibility and use with the E.P.D.M. single ply membrane roofing system and its bonding adhesive. (Refer further to TECHNICAL PROVISIONS, Section 6).

1.1.3 Roofing. - The roofing system shall be a bonded - "Ethylene Propylene Diene Monomer" (E.P.D.M.) membrane in accordance with Technical Provisions, Section 3, entitled "Elastomeric Roofing" (EPDM).

1.2 Area "B". - Mess hall/kitchen wing - about 7,000 square feet. This new roof system shall consist of the following:

1.2.1 Vapor Barrier. - The vapor barrier is to be applied directly to the primed concrete roof deck after priming the concrete surfaces. It shall consist of an asphalt saturated and coated inorganic felt; coated base sheet (No. 43) Type I (plain) per A.S.T.M. Specification D-2626. The vapor barrier sheet shall be uniformly mopped to the deck with hot asphalt at 25 pounds per square and then top coated with an additional mopping of hot asphalt at the same rate (Refer to TECHNICAL PROVISIONS, Section 7).

1.2.2 Urethane insulating foam sprayed directly, after priming, over the vapor barrier, per Technical Provisions, Section 4, entitled "Elastomeric Roofing-Fluid Applied". The urethane foam thickness shall be adequate to provide a thermal insulating "R" value of 19 (2-3/4" to 3" thick).

1.2.3 Top surface protective coating(s) shall be Silicone or Catalyzed Urethane, all per Technical Provisions, Section 4, entitled "Elastomeric Roofing-Fluid Applied".

1.2.4 Top surface granule finish per Technical Provisions, Section 4, entitled "Elastomeric Roofing-Fluid Applied". Color of granule surfacing to be selected by Contracting Officer.

1.3 Area "C". - Easterly, one story part of east west wing Confinement Building, about 6,500 square feet. This new roofing system shall consist of a conventional built-up roof with mineral surface cap sheet over rigid inorganic closed cell insulating board, over thermal setting insulating fill (lightweight asphaltic concrete) over a vapor barrier applied directly to the primed-existing concrete roof deck. More specifically, the new roofing system shall consist of the following:

1.3.1 Vapor Barrier. - The vapor barrier is to be applied directly to the primed concrete roof deck after priming the concrete surfaces. It shall consist of an asphalt saturated and coated inorganic felt (coated base sheet (No. 43) Type I (plain) per A.S.T.M. Specification D-2626). The vapor barrier sheet shall be lapped in accordance with Table I and uniformly mopped to the deck with hot asphalt at 25 pounds per square and then top coated with an additional mopping of hot asphalt at the same rate. (Refer to TECHNICAL PROVISIONS, Section 7).

1.3.2 Thermal Setting Insulation Fill (light weight insulating asphaltic concrete). - The insulating fill shall be placed over the vapor barrier and compacted in place to thicknesses and slopes necessary to provide roof drainage. Top surfaces of the insulating fill shall allow achieving the finished roofing elevations of the existing roof (as shown on drawing 27-07-04 sheet 2 of 31) after installation of 1-1/2" rigid board insulation over the thermal setting insulating fill. The thermal K factor of the insulating fill shall not exceed $K=0.40$ ($R=10$ for 4" thickness). The installed density of the insulating fill shall not exceed 22 pounds per cubic foot.

1.3.3 Rigid Insulation Board. - Two courses of rigid insulating board shall be applied over the thermal setting insulating fill. Total thickness of the rigid insulation shall be 1-1/2". The thermal "K" value of the rigid insulation shall not exceed 0.167 ($R=9$ (minimum) for 1-1/2" thickness). Composition of the rigid board insulation shall be closed cell, inorganic, moisture impervious in accordance with Technical Provisions, Section 6. The rigid insulation board layers shall be applied to the insulating fill and to itself by hot mopping with asphalt at the rate of 25 pounds per square. (Refer further to TECHNICAL PROVISIONS, Section 6).

1.3.4 Roofing. - The roofing shall be applied over the rigid insulation board and shall be four ply roofing of asphalt saturated inorganic felt employing a mineral surface (no gravel) cap sheet all in accordance with Technical Provisions, Section 5, "Built-Up Roofing". The four ply inorganic roofing with mineral surface cap sheet shall consist of the following:

- | | |
|-------------------------------------------------------------------------------------|-----------|
| 1 - Ply No. 11 asphalt impregnated glass fiber felt (Base sheet) | 11 pounds |
| 2 - Ply No. 11 asphalt impregnated glass fiber felt (intermediate) | 22 pounds |
| 1 - Ply 72 pounds mineral surface, asphalt impregnated - glass fiber felt cap sheet | 72 pounds |
| 4 - Hot moppings of steep asphalt | 92 pounds |

SECTION 3 - ELASTOMERIC ROOFING (EPDM)

1. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

1.1 American Society for Testing and Materials (ASTM) Publications. -

D 3253

Vulcanized Rubber Sheeting for Pond,
Canal and Reservoir Linings.

2. GENERAL. - Bonded Ethylene Propylene Diene Monomer (EPDM) roofing shall be applied to the roof surfaces indicated. Roofing membrane shall be furnished in the largest sheets possible to minimize joints. All materials used for the roofing system shall be the products of a single manufacturer. Membrane shall be free of any pinholes, lumps and foreign material.

2.1 Standard Product. - The EPDM roofing system including flashing shall be the standard product of a single manufacturer regularly engaged in the production of this type of product, such as Carlisle Company "Sure-Seal" R Universal Roofing System or approved equal.

2.2 Delivery and Storage. - Materials shall be delivered to the job site in the manufacturer's original, unopened packages, clearly marked with the manufacturer's name, brand name, and description of content. Materials shall be stored in clean, dry areas at a temperature between 60 degrees F and 80 degrees F. Facilities for storing the materials shall be furnished by the Contractor at site adjacent to the work to be designated by the Contracting Officer or his representative.

2.3 Coordination. - Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous-roof surfacing operations. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is weatherproofed the same day with the completed roofing system.

2.4 Preparation for Reroofing. - Existing roof deck shall be stripped of roofing system, insulation, flashing, and cants. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at end of each working day.

3. SUBMITTALS. - Contractor shall submit the following in accordance with the TECHNICAL PROVISIONS, Section 1A, GENERAL.

3.1 Certificates of Compliance attesting that the materials meet specification requirements.

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3.2 Qualifications of Installer. - Certificate from manufacturer identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's Instructions for installation of the membrane, including procedures for preparing the membrane for use, flashing, splicing, and bonding of the membrane.

3.4 Samples of membrane materials shall be submitted for testing by the Government. A 1-foot wide, full width sample shall be furnished from the end of each piece of EPDM membrane placed on the roof. In addition, 200 square feet of representative samples of the EPDM membrane used shall be furnished. An 18-inch long by 12-inch wide sample of the seam formed by connecting adjacent sheets of EPDM membrane shall be furnished from the first 100 feet of seam constructed plus an additional sample the same size from each additional 300 feet of seam constructed. In addition, 20 feet of seam 1-foot wide formed by connecting two sheets of EPDM shall be furnished. One quart of each bonding adhesive, one cartridge of sealant, and 1 pound of fasteners shall also be furnished.

3.5 Shop and Installation Drawings Showing The Following. -

3.5.1 Plan View of roof area including dimensions of size locations and types of roof penetrations, perimeter and penetration details and a bill of materials.

3.5.2 Shop Drawings showing size of sheets, position of sheets and splices, flashing details and nailing sheets.

4. MATERIALS. -

4.1 Membrane shall be .060 inch thick, and shall comply with ASTM D 3253, Type II, except as follows:

<u>PROPERTY</u>	<u>VALUE</u>
Tensile strength	1400 psi minimum
Tear Resistance	125 pounds per inch minimum
Heat Aging (Accelerated) Elongation	210% minimum
Brittleness	-50 Degrees F. minimum
Ozone Resistance	No cracks
Permeability, Water Vapor	2.0 perm-mils

4.2 Adhesives. - Cements and sealants shall be of types recommended by the roofing membrane manufacturer.

4.3 Wood nailers shall be number 2 or better grade lumber and shall be water-borne preservative treated.

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CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 13/13

CONSTRUCTION OF EXPERIMENTAL ROOFING. (U)

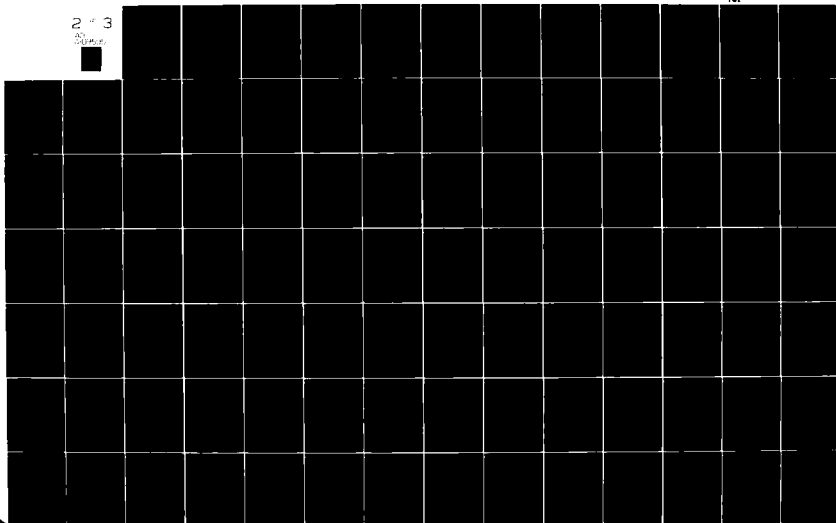
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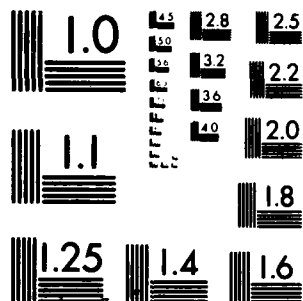
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A.

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4.4 Insulation shall be closed cell, inorganic board insulation as specified in Technical Provisions, Section 2, paragraph 1.1.2 - The Insulation shall be approved for use by the manufacturer of the EPDM Roofing System to which it will be bonded.

4.5 Fasteners. - Nails and fasteners used with flashing and nailers shall be of the types and sizes best suited for the job and shall comply with roofing manufacturer's approved instructions.

4.6 Flashing shall be of durable elastomeric material compatible with the membrane specified, as furnished by the roofing manufacturer.

4.7 Prefabricated accessories such as pipe seals shall be of types and sizes recommended by the roofing membrane manufacturer.

5. INSTALLATION. - Installation shall comply with the manufacturer's approved instructions and shop drawings, except as otherwise specified.

5.1 Nailers shall be installed on the perimeter of roof surfaces, curb flashing, skylights, expansion joints and similar penetrations, and to divide the roof into segments not exceeding 1600 square feet each. Thickness of nailers shall be such that top of nailers is flush with the surface to which the membrane is to be applied. The nailers shall be firmly attached to resist a force of 75 pounds per linear foot in any direction.

5.1.1 Wood Nailers. - Wood nailers shall be surface mounted to the concrete deck before application of insulation. Top of nailers shall be flush with the final insulation surface. Wood shall be treated with a water-borne preservative. Nailers for Area "A" shall divide the deck into 1600 square foot maximum section. Nailers shall be mechanically anchored to the concrete deck. Mechanical fasteners shall be 3/8 inch diameter and spaced not over 4 feet on centers. Bolt anchors shall have nuts and washers counter sunk, and bolts shall be cut flush with top of nailer. Bolts entered from top shall have washers and bolt heads counter sunk. Powder-actuated fasteners, sized and spaced for nailer anchorage equivalent to that specified and indicated, may be used with written approval of the Contracting Officer, and only in the structural concrete deck of Area "A".

5.2 Insulation shall be placed completely covering the roof. Insulation shall be fastened with hot asphalt in accordance with SECTION 6, Thermal Insulation for Use With Experimental Roof System. Insulation around drains shall be tapered to provide a smooth transition between roof surface and drain clamping ring.

5.3 Membrane shall be fastened in place and sealed to adjoining sheets using minimum 3 inch wide laps. Direction of lap shall be such that water flows over lap. Wrinkles shall not extend into terminations or field splices. Membrane shall be sealed to drain bases. Nails fastening membrane to nailers forming the 1600 square feet grid shall be covered with 6 inch wide strips of sheeting. Membrane must be relaxed for at least one half hour, then repositioned in place to remove wrinkles before bonding.

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5.4 Splices. - Mating surfaces shall be cleaned with heptane, or with unleaded or white gasoline. Splice edges shall be cleaned of adhesive with solvents and sealed.

5.5 Nailing. - Membrane shall be mechanically fastened to all nailers using roofing nails. When using a vertical nailer, the nailer shall be installed over the membrane flush with the roof surface, securing the membrane at the horizontal plane. Spacing of nails and covering of nail heads shall be in accordance with recommended details of the EPDM roofing manufacturer.

5.6 Flashing. - All projections and changes in roof planes shall be flashed. The splice between the flashing and the main roof sheet shall be completed before bonding the flashing to the vertical surface. The splice shall be sealed a minimum of 3 inches beyond the fasteners which attach the membrane to the horizontal nailer. The installed flashing shall be nailed at the top of the flashing a maximum of 12 inches on center under the metal counter-flashing or cap. Factory prefabricated pipe seals shall be used to flash all pipe where installation is possible. Flashing details shall comply with details recommended by the manufacturer of the EPDM single membrane roofing system.

5.7 Cut-Offs. - If work is terminated prior to weatherproofing the roof, the insulation line shall be straightened using loose-laid cut sheets and the membrane shall be sealed to the roof deck. Membrane shall be pulled free or cut to expose the insulation when resuming work and cut insulation sheets used for fill-in shall be removed.

6. INSPECTION. - All joints shall be inspected over entire length after completion and all defective areas resealed. Damaged areas of membrane shall be removed and recovered, lapping underlying membrane by at least 3 inches on all sides. The roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications. Submit certificate to the Contracting Officer.

7. WARRANTIES for the Roofing System shall be provided in accordance with the applicable provisions of the General Specifications.

SECTION 4 - ELASTOMERIC ROOFING, FLUID APPLIED

1. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designations only, form a part of this specification to the extent indicated by the references thereto:

1.1 American Society for Testing and Materials (ASTM) Publications. -

C 177	Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate.
C 726	Mineral Fiber Roof Insulation Board.
C 728	Perlite Thermal Insulation Board.
D 312	Asphalt for Use in Constructing Built-Up Roof Covering.
D 1621	Compressive Properties of Rigid Cellular Plastics.
D 1622	Apparent Density of Rigid Cellular Plastics.
D 2626	Asphalt-Base Sheet for Use in Construction of Built-Up Roofs.
D 2822	Asphalt Roof Cement.
E 96	Water Vapor Transmission of Materials in Sheet Form.

1.2 Underwriters' Laboratories, Inc., Publication. -

UL 790	Tests for Fire Resistance of Roof Covering Materials.
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2. GENERAL. - The roofing system shall consist of a layer of sprayed-in-place urethane foam roof insulation covered with a two-coat elastomeric coating. The system shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage. - Materials shall be delivered to the job site in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials shall be stored in clean and dry areas. Storage facilities shall be provided by the Contractor at a site adjacent to the work area to be designated by the Contracting Officer.

2.2 Coordination. - Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations.

2.3 Preparation for Reroofing. -

2.3.1 Removal. - Debris from existing roof shall be removed using a covered chute or other device to minimize spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made at contractor's expense. Ground around chute shall be cleaned immediately after completion of removal activities.

2.3.2 Cleaning. - Prepared roof area shall be cleaned with compressed air using three passes, each at a right angle to the preceding one. Last pass shall be made immediately prior to application of new roofing system. Debris accumulated shall be dumped down the chute. Prevent loss of debris around the perimeter of the building.

2.3.3 Protection. - The roof shall be completely weatherproofed at the end of each work day. Removal activities shall be limited to that area which can be reroofed during the same day.

2.3.4 Stripping. - Existing roof deck shall be stripped of roofing system, insulation, flashing, and cants. Surface shall be cleaned and prepared for installation of the vapor barrier. Defective treated wood blocking nailers and cants shall be inspected for soundness and be replaced if found defective.

2.3.5 Priming. - After installation of vapor barrier, surfaces shall be primed at an application rate recommended by the roofing manufacturer.

2.4 Over-Spraying. - Construct barriers or take other measures to prevent overspraying and be responsible for damages resulting from overspraying.

3. SUBMITTALS. - The following shall be submitted in accordance with the Technical Provisions - Section 1A - GENERAL.

3.1 Certificates of Compliance attesting that the materials meet the specification requirements, and certificate from coating manufacturer certifying that coating and foam system being supplied has been tested and meets the requirements of UL 790.

3.2 Qualifications of Installer. - Certificate from the foam and coating manufacturers identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's instructions for installation of the foam and coating roofing system.

3.4 Samples shall be submitted as follows for independent Government testing:

Each component of foam and 5 gallon container.
protective coating.

Granules. 10 pounds.

Primer. 1 gallon.

Sealant. 102 1 cartridge.

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Foam with coating. 6 samples (2 ft x 2 ft)¹

Foam with coating and wearing course. 2 samples (2 ft x 2 ft)¹

¹Constructed as described in paragraph 7.3.

4. MATERIALS. -

4.1 Urethane Foam. - Cured foam shall conform to the following properties:

<u>PROPERTY</u>	<u>TEST METHOD</u>	<u>VALUE</u>
Density, lb/ft ³ overall	ASTM D 1622	2.7 min., 3.5 max.
Compressive Strength, psi parallel to rise	ASTM D 1621	40.0 min.
Thermal Conductivity (k factor) Btu/hr/ft ² /°F/min	ASTM C 177	new 0.11 max. aged 0.15 max.

4.2 Protective coating system shall be one of the following permeable types with a maximum perm rating of 3.5 when tested as specified in ASTM E 96, procedure B.

4.2.1 Silicone weather coating, manufactured by General Electric Company (medium gray base coat SCM 3308/501C and cement gray top coat SCM 3304/3307C).

4.2.2 Silicone 3-5000 Construction Coating manufactured by Dow Corning Company (light gray base coat and white top coat).

4.2.3 Catalyzed urethane, IRATHANE Weather/Flex Plus manufactured by Irathane Systems (urethane base coat of IRATHANE 300 and a hypalon top coat of IRATHANE 157).

4.3 Granules. - No. 11 screen size, ceramic coated, in colors provided by the manufacturer.

4.4 Roofing Felt. - ASTM D 2626, Type I.

4.5 Primer and sealer shall be of the type recommended by the coating manufacturer.

4.6 Asphalt. - ASTM D 312, Type III.

4.7 Bituminous cement. - ASTM D 2822, Type I.

5. INSTALLATION. - Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

5.1 Urethane foam shall be sprayed on the prepared deck to a minimum thickness of one inch except where variations are needed to provide

adequate thermal insulation and to ensure drainage. Foam shall be applied in 1/2 inch lifts. Time between lifts shall not exceed 4 hours. The finished surface shall be smooth and free of voids, crevices, and pinholes. Foam with surface condition known as "tree bark" or "popcorn" shall be removed and replaced at the contractor's expense. Foam shall be extended up walls and around roof projections to form cants and flashings that terminate at least 2 inches above finished roof surface. Foam shall be cured and free from water, dust, oils, and other materials which would impair adhesion of coating. No foam shall be allowed to stand overnight without a base protective coating. Foam shall cure at least one hour before application of protective coating.

5.1.2 The finished surface of the urethane foam shall be flat and sloped uniformly to assure drainage after application of the protective coatings. Pockets or depressions that allow any ponding of water on the completed roof shall require correction to assure complete drainage.

5.2 Protective Coating. - Coatings shall be applied and cured in accordance with manufacturer's instructions. Coating shall consist of a base coat and top coat. Base coats exposed for more than 24 hours shall be cleaned with a detergent solution, rinsed thoroughly, allowed to dry, and recovered with base coating.

5.2.1 Base coat shall have a minimum dry thickness of 10 mils for silicone, or 15 mils for Irathane. Coating shall completely cover the foam and extend up vertical surfaces 2 inches beyond foam. Coating shall be dry and clean before application of top coat.

5.2.2 Top coat shall be applied at right angles to the direction of the base coat application. Total dry film thickness shall be 20 mils minimum. Film thickness shall be verified by taking samples as specified below. Sample areas shall be recoated to restore film. Foam with "orange peel" or "coarse orange peel" surfaces shall have additional coating applied as required to obtain minimum dry film thickness.

5.3 Flashing. - Areas to be flashed shall be dry and free from all dust, dirt, tar, oils, and other debris. Metal surfaces shall also be free from all rust. Termination points requiring flashing shall be caulked with manufacturer's recommended sealant. Coating shall then be applied at a rate of 1 gallon per 100 square feet to an area a minimum of 4 inches on either side of the sealant. After flashing system has cured, 2 additional coats shall be applied to flashing areas during normal coating operations.

5.4 Granules. - Granules shall be applied within 5 minutes of top coat application, using pressure equipment, at a rate of 50 pounds per 100 square feet. Granules shall be applied in a minimum of 2 passes at right angles. Finished granule system shall be uniform over entire surface with no apparent void areas. No traffic shall be allowed on finished area for 24 hours after granule application is completed.

5.5 Service Walks. - If required, service walks shall be applied after the 2-coat system has been completed and cured. Reinforcing fabric 24 to 48 inches wide and as standard with the coating manufacturer shall be set into

a third layer of the coating and smoothed with brush or roller. Fabric shall then be coated with the base coating to a minimum of 6 inches beyond each edge, completely covering the fabric so that none of it is exposed. No traffic shall be allowed in the area for 48 hours after installation.

6. EQUIPMENT CALIBRATION. - Spray equipment for two-component systems shall be calibrated each day at start of operations, each restart if spraying operations have been terminated for more than one hour, if there is a change in fan pattern, change in pressure, slow curing areas are noticed, change in work area requiring a change in hose length or in working height, after changing or cleaning filter elements, after changing curing agents, after changing between protective coatings, and whenever directed by the Contracting Officer. Calibration shall consist of demonstrating that the equipment is adjusted to deliver components in the proportion and at rate specified in approved manufacturer's instructions. Calibration tests shall be accomplished on the roof adjacent to the area to be sprayed.

7. CONTROL SAMPLES. - Immediately following satisfactory completion of each calibration procedure, collect samples as specified below. The date, time of day, and material identification of each sample layer shall be clearly marked.

7.1 Foam. - Prepare wooden open-top boxes 24 inches square by depth of finished roof section. Boxes shall be filled in 1/2 inch lifts during actual roof foaming, each lift being collected at the same time it is applied to the roof.

7.2 Protective Coating. - Samples shall be collected after each calibration and at least once per ten squares of application in a continuous operation. Place two Government furnished test plates in path of spray operations, remove them after being sprayed, and respray areas to repair coating. Wet thickness shall be determined from one plate; if deficient the contractor shall be directed to take corrective action. The 24 inch square foam samples shall be coated in the same manner.

7.3 Wearing Course. - Two of the 24 inch square samples shall consist of the completed roof system including wearing course.

7.4 Frequency. - A minimum of two additional samples of the completed roof system, including coating shall be provided, and additional samples may be taken at any time at the direction of the Contracting Officer.

8. INSPECTION. - Foam surface will be inspected for texture, blisters, non-adherence to substrate, and other defects before finish coating is applied. All pinholes shall be finished flush with sealant recommended by the coating manufacturer. Roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications.

9. WARRANTIES. - Warranties shall be provided in accordance with applicable provisions of the General Provisions Section of these specifications.

SECTION 5 - BUILT-UP ROOFING

1. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

1.1 American Society for Testing and Materials (ASTM) Publications. -

C 208	Insulating Board (Cellulosic Fiber), Structural and Decorative.
D 41	Primer for Use with Asphalt in Damp- proofing and Waterproofing.
D 226	Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built- Up Roofs.
D 250	Asphalt-Saturated Asbestos Felts for Use in Waterproofing and in Constructing Built-Up Roofs.
D 312	Asphalt for Use in Constructing Built-Up Roof Coverings.
D 517	Asphalt Plank.
D 1751	Preformed Expansion Joint Fillers for Concrete Paving and Structural Con- struction (Nonextruding and Resilient Bituminous Types).
D 2178	Asphalt-Impregnated Glass Fiber Mat (Felt)
D 2626	Asphalt-Base Sheet for Use in Construction of Built-Up Roofs.
D 2822	Asphalt Roof Cement.
D 3617	Sampling and Analysis of New Built-Up Roof Membranes.

1.2 Federal Specification. -

SS-R630-D & Int. Am. 2	Roofing Felt (Roll, asphalt prepared, mineral surfaced).
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2. GENERAL. - Asphalt bitumen inorganic glass fiber felt built-up roofing shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage of Materials. - Roofing materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Felts and

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roll roofing shall not be exposed to any moisture before, during, or after delivery to the site. Felts and roll roofing shall be stored in an enclosed building or in a trailer, stacked on end, and maintained above 50 degrees F for 24 hours immediately before laying. Storage facility shall be provided by the Contractor at a site adjacent to the work to be designated by the Contracting Officer or his representative.

2.2 Coordination Requirements. - Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations the same day felts are installed. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is waterproofed the same day with the complete roofing system.

2.3 Preparation for Reroofing. - Existing roof deck shall be stripped of roofing membrane, insulation, vapor barrier, cants, embedded flashing, nails, fasteners, and deteriorated nailers. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at end of each working day.

2.4 Application Requirements. - Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. The roofing or flashing shall be applied to a smooth and firm surface free from ice, frost, moisture, dirt, and foreign materials. Application of roofing shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40 degrees F.

2.5 Bituminous-plastic-type flashings installed in accordance with these specifications shall be used throughout unless otherwise specified or indicated.

3. SUBMITTALS. -

3.1 Certificates of Compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the Technical Provisions, Section 1A, GENERAL.

3.2 Manufacturers installation instructions shall be submitted and approved prior to delivery of materials to the site. Instructions shall specify acceptable range of bitumen application temperatures. Bitumen manufacturer shall specify maximum temperature for holding bitumen in a heated condition.

3.3 Temperature Control Equipment. - Submit manufacturer's literature on the automatic temperature recorder and automatic thermostatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting that the recorder, automatic temperature control, and portable thermometer were each tested immediately prior to shipment to the site and that all operate

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within the accuracy tolerances given in the manufacturer's specifications. Temperature control and recording equipment shall be in proper working condition during use.

3.4 Samples. - The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

Felts - 1-7 ft sample from end of each roll
Bitumen - 10 pounds of each type used
Primer - 1 gallon
Bituminous cement - 1 gallon
Nails, fasteners, and anchors - 1 pound of each type, size, and style
Asphalt plank - 1 square foot

4. MATERIALS. -

4.1 Asphalt Primer. - ASTM D 41.

4.2 Asphalt. - ASTM D 312 Type III.

4.3 Cants and Nailers. -

4.3.1 Cants shall be made from treated wood or treated fiberboard and shall reduce the angle covered into two equal angles. Treated wood shall be of water-borne preservative-treated material. Fiberboard shall conform to ASTM C 208 treated for moisture resistance by integral treatment with wax or other sizing or with bituminous impregnation.

4.3.2 Treated Wood Nailers where required for mechanical fastening of felts at roof perimeter and at roof penetrations shall be installed with their top surfaces flush with top surface of the rigid insulation board. The nailers shall be installed in the top surface of the insulated asphaltic fill and shall be set in a continuous layer of bituminous cement before fastening.

4.4 Felt shall be the asphalt saturated type and shall conform to the following requirements:

4.4.1 Glass Roofing Felt. - ASTM D 2178, type I.

4.4.2 Asbestos Roofing Felt. - ASTM/250, type 1.

4.4.3 Glass Roll Roofing. - Federal Specification SS-R-630, Cl. 3 with 2" selvage end.

4.4.4 Asphalt-Saturated Base Sheet. - ASTM D 2626, Type I or II.

4.5 Nails, fasteners, and anchors shall be an approved type recommended by the roofing felt manufacturer. Fasteners for securing roofing felts to mineral-fiber, expanded polystyrene or fiberboard insulation, concrete, and gypsum surfaces shall provide a minimum holding power of 20 pounds each when installed.

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4.6 Roofing Cement. - ASTM D 2822, Type I.

4.7 Asphalt Plank. - ASTM D 517, 1" thick, mineral surfaced.

5. ASPHALT BUILT-UP 4-PLY INORGANIC ROOFING. -

5.1 On Insulation Surfaces. - Three plies of roofing felt shall be mopped in solid with hot asphalt. Felts shall be laid shingle-fashion at right angles to the direction of the roof slope and lapped in accordance with Table I. One ply of mineral surfaced roll roofing shall then be applied without nailing. Roll roofing shall be cut and stacked when not machine applied. The flashings shall be installed.

6. APPLICATION OF ROOFING. -

6.1 General Requirements. - The entire roofing system shall be finished in one operation up to the line of termination at end of day's work. Application of roofing shall immediately follow application of insulation as a continuous operation. Phased construction will not be permitted. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen.

6.2 Detail Requirements. -

6.2.1 Prior to application of roofing, concrete surfaces to receive asphalt products shall be primed at a rate of not less than 1 gallon per square. Bitumen shall uniformly cover all roof areas to be mopped to provide effective bond.

6.2.2 Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

6.2.3 Bitumen stops formed of edge envelopes shall be installed at eaves and rakes. Envelopes shall be formed of two 18-inch wide layers of organic or asbestos roofing felt. Nine inches of the width shall be attached to the roof surface with 9 inches extending beyond the edge. The first layer shall be applied in a 4-inch wide layer of roofing cement and nailed 1/2-inch from the roof edge at 6-inch spacing. The second layer shall be applied to the first in a 9-inch wide mopping of bitumen. The free edges shall be protected from damage throughout the roofing period.

6.2.4 Application and holding temperature shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers. Each layer of roofing felt shall

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be laid in not less than 15 pounds of asphalt per square or more than 25 pounds of asphalt per square. Final layer of roll roofing shall be laid in not less than 20 nor more than 30 pounds of asphalt per square. Roll roofing shall not be nailed.

6.2.5 Layers of roofing shall be laid free of wrinkles, creases or fishmouths, at right angles to the slope of the deck, immediately behind the applicator. The surface of the felts shall be broomed-in full width to obtain complete adhesion between plies and to eliminate air pockets. Brooms shall have soft bristles and shall be discarded when the bitumen build-up on the fiber prevents application of equal pressure across the broom width on felts. The method of mopping a half-sheet width and turning the sheet back to mop under the other half will not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 4 inches, or to the top of the cant strip. After the last ply of roofing felt is applied, the edge envelope shall be formed by folding back and mopping each layer. The gravel stop shall be embedded in bituminous cement and nailed on top of the envelope or membrane. Existing gravel stop is intended to be reused provided it is not damaged during preparation for reroofing.

6.2.6 Each course of roofing felts, in addition to being mopped in hot bitumen, shall be lapped as specified in Table I and nailed as specified in Table II whenever slope exceeds 1/2" per foot. Side laps shall be 2" and end laps 4" for mineral surfaced roll roofing.

6.2.7 Nails and fasteners for securing roofing shall be flush-driven through flat metal disks of not less than 1-inch diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 1-inch diameter disks.

6.2.8 At end of each day's work or whenever precipitation is imminent, the terminated edge of built-up roofing shall be sealed with two full width strips of felt set in bituminous cement. Cut insulation pieces shall be temporarily laid in place to straighten the exposed edge of insulation. Extend half-width of strips up and over the finished roofing or insulation and extend the other half-width out and onto the bare roof deck surface. Water cutoffs and temporary insulation pieces shall be removed before continuing installation of roof system. Extra full-width strips of felt shall be used as needed to insure complete covering of insulation.

7. FLASHINGS. - Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous-plastic-type flashings described below shall be used, except where metal flashings are indicated or specified. Flashings shall be installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends. Flashings shall be stepped where vertical surfaces abut sloped-roof surfaces.

7.1 Base Flashings. - Materials and installation shall be in accordance

with the approved recommendations of the roofing felt manufacturer. Base flashings shall consist of two plies of glass felt and one ply of a mineral surface roll roofing.

7.1.1 Cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have a 5-1/2 inch face dimension and shall be continuous and installed in lengths as long as practicable. Cants are not required at locations where cast-in-place cants are integrally formed with the structural deck or roof fill. Cants shall be mitered at all changes of direction.

7.2 Strip Flashings. - Roof flanges of lead and sheetmetal flashings, such as gravel stops, base flashings, and plumbing flashings, furnished and installed under other sections of the specifications, shall be stripped with two layers of glass roofing felt set in plastic cement. After installation of flanges of flashings over the top ply of roofing, the strip flashings, consisting of two layers of roofing felt, 9 and 12 inches wide, shall be successively cemented to the top of the roof flange using bituminous plastic cement, to form a waterproof joint between roofing and flashings. A final strip of roll roofing 15" wide shall then be applied using bituminous plastic cement.

7.3 Valleys. - Felt plies shall continue across valleys and terminate approximately 12 inches from the valley. Exposed lap shall terminate on a line approximately 12 inches from, and parallel to, the valley gutter. Two plies of felt, 9 and 12 inches wide, shall be successively mopped-in over each felt line of termination.

8. COMPOSITION-TYPE TRAFFIC SURFACES. - If required, mineral-surfaced asphalt plank treads shall be embedded in the flood coat prior to aggregate surfacing. Planks or treads shall be spaced 6 inches apart.

9. QUALITY ASSURANCE. -

9.1 Reverification of Temperature Controls. - Verify the accuracy of the temperature recorder each work day before using bitumen from kettle or tanker using a portable thermometer.

9.2 Charts and Records. - Provide daily the chart from the temperature recorder and evidence that the recorder accuracy was verified.

9.3 Application Temperatures. - Furnish a daily record indicating the application temperature of each bucket of bitumen accepted on the roof.

9.4 Roof Cutout Samples. - Roof sampling shall comply with ASTM D 3617 except that one sample shall be taken for each 10 squares (1000 square feet) of roofing, and also as directed by the Contracting Officer when there is reason to believe that deficiencies exist. Sample dimensions shall be 4 inches by 36 inches. Length of sample shall be taken across the felts. The Government will test the sample for head laps, weight, free water, and existence of voids. The hole in the roofing membrane shall be flooded

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with hot bitumen, and a new section of equivalent size and structure shall be built in the hole. The sample area shall be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the sample area 3 inches on all sides and each succeeding ply overlapping the preceding 3 inches on all sides. If the sample indicates a deficiency, take additional samples to determine the extent of the deficiency. Deficient roofing shall be removed and replaced. A sample shall be taken from replaced roofing.

TABLE I

LAPS FOR ROOFING FELTS AND ROLL ROOFING(a)

Layers or plies	Laps in inches for 36-inch width	Starting widths in inches for 36-inch width
1	4	36
3	24-2/3	12, 24 and 36

(a) End laps of roofing felts and roll roofing shall be not less than 6 inches and shall be staggered a minimum of 12 inches.

TABLE II

NAILING OF BUILT-UP ROOFING LAID ON INSULATION

Expanded-Perlite, Fiberboard, or Mineral-Fiber	Composite Board, Cellular Glass, or Urethane
Nail 12" on centers into insulation staggered in two rows 2" and 6" from upper edge.	Nail into surface mounted roof nailing strips provided and installed in SECTION: INSULATION FOR BUILT-UP ROOFING. Nail each ply at 2", 5", and 8" from upper edge with nails penetrating at least 3/4" into nailing strips.

SECTION 6

THERMAL INSULATION FOR USE WITH EXPERIMENTAL ROOF SYSTEMS

1. RIGID BOARD INSULATION used only in Area "A" under the single ply elastomeric roofing (E.P.D.M.) and under the built-up roofing in Area "C" shall be inorganic, closed cell, fiber and binder rigid board stock and shall have the following physical characteristics unless otherwise stated in these specifications:

1.1 RIGID INSULATION BOARD STOCK - REQUIRED PHYSICAL CHARACTERISTICS

<u>Characteristic</u>	<u>Test Method</u>	<u>Properties</u>
Thermal Insulation "K" Factor	ASTM C 177	0.15 (Maximum)
Compressive Strength	ASTM D 1621	25 p.s.i. (Minimum)
Moisture Vapor Transmission	ASTM C 355	25 perm. In. (Maximum)
Water Absorption	ASTM C 209	2.0% by volume (Maximum)

1.2 Insulation board which produces chemically toxic fumes during combustion may be rejected at the discretion of the Contracting Officer.

2. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

2.1 American Society for Testing and Materials (ASTM) Publications. -

C 726	Mineral Fiber Roof Insulation Board
C 208	Insulating Board (Cellulosic Fiber) & Structural & Decorative)
D 312	Asphalt Used for Roofing
D 2822	Asphalt Roof Cement

3. DELIVERY AND STORAGE OF MATERIALS. - Materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Insulation shall not be exposed to any moisture before, during or after delivery to the site. Insulation shall be stored in an enclosed building or in a trailer. Wet materials shall not be used and shall be removed from the worksite.

4. SUBMITTALS. - As specified in SECTION 5 - BUILT-UP ROOFING.

5. APPLICATION OF INSULATION. -

5.1 Installation Requirements. -

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5.1.1 Insulation shall be laid in two layers in Area "A" and Area "C". Units of insulation shall be laid in parallel courses parallel to the roof slope. End joints shall be staggered. Joints in second layer shall be staggered with respect to joints in first layer. Insulation shall be cut to fit neatly against adjoining surfaces. Insulation which can be readily lifted after installation is not considered to be adequately secured. Insulation pattern is illustrated in Fig. 1.

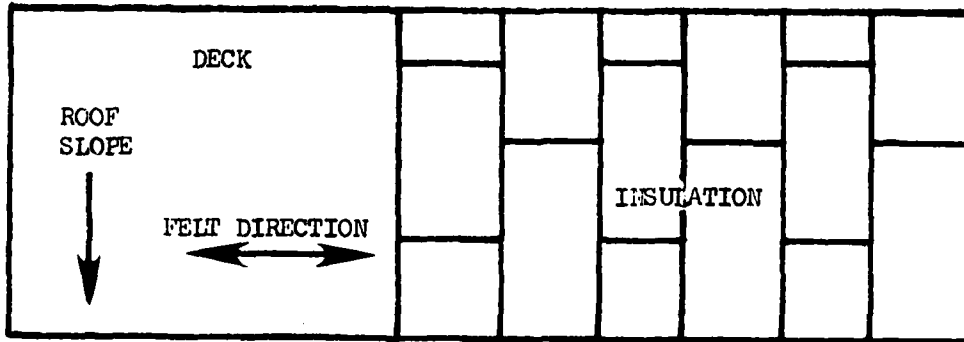


Fig. 1 - INSULATION PATTERN

5.1.2 Bitumen shall not be applied further than one panel length ahead of roof insulation being installed. All bare areas in concrete decks shall be primed with asphalt primer at a rate of 1 gallon per 100 square feet. All layers of insulation shall be laid in solid moppings of hot asphalt applied at the rate of 25 pounds per square maximum.

5.2 Protection Requirements. - The insulation shall be kept dry at all times and shall be laid just before application of the membrane. No more insulation shall be laid than can be covered the same day with the complete roofing system. Exposed edges of the insulation shall be protected by cutoffs at the end of each day's work or whenever precipitation is imminent. Cutoffs shall be as specified in SECTIONS 3 and 5. Cutoffs shall be removed when work is resumed.

5.2.1 Storage facilities for rigid insulation board shall be provided by the contractor at a site adjacent to the work site to be designated by the Contracting Officer.

SECTION 7 - VAPOR BARRIERS

1. VAPOR BARRIER shall be applied to roofing areas "A", "B" and "C".

1.1 The vapor barrier shall consist of one ply of asphalt-saturated inorganic base sheet, mopped on at right angles to the direction of slopes. Base sheet shall be solid mopped directly to the primed concrete deck. Plies shall be lapped as specified in Table I of SECTION 5. Plies shall be laid in 25 pounds of asphalt per square. Base sheet shall be broomed-in full width to obtain complete adhesion and eliminate air pockets. The method of mopping a half-sheet width and turning the sheet back to mop under the other half shall not be used.

1.2 Asphalt temperatures shall be controlled as specified in SECTION 5 - BUILT-UP ROOFING.

1.3 After removal of old roofing, all bare concrete areas shall be primed with not less than 1 gallon per square of asphalt primer.

1.4 Vapor Barrier shall be mechanically fastened to roof deck at perimeter of roof and at roofing penetrations. When nailing to wood blocking is employed nailing shall comply with Table II, SECTION V of the Technical Provisions.

AFZH-FEPSD-E

Contract No. DAKF57-79-0265 (Scholten Roofing, Inc.)

//THRU Finance & Accounting Office DFAE
ATTN: Accounting Branch

Mr. Leonard/5025
Mr. Zuchowski/md/5423

TO Contracting Office

1. Reference:

a. Contract No. DAKF57-79-C-0265, Experimental Reroofing Post Stockade Bldg. Ft. Lewis (IJO BB00098-9J) (Spec 3529-R1).

b. Letter, Scholten Roofing, Inc., dated 17 Oct 79, RE: Contract DAKF-57-79-C-0265, Re-Roofing Post Stockade, Bldg #1450.

c. DF, AFZH-DIP, 9 Nov 79, subject: Correspondence from Contractor, Contract Number DAKF57-79-C-0265, Spec. No. 3529 R1, by means of which you forwarded for DFAE's consideration Material Approval Submittal Number 2 as well as copy of letter, reference 1.b., above. Correspondence requested, additionally, that DFAE provide a list of submittals still required from the contractor.

d. DF, AFZH-DIP, 18 Dec 79, subject: Experimental Re-Roofing of Post Stockade Spec. No. 3529, R1, DAKF57-79-C-0265, requesting status of DFAE's processing of Material Approval Submittal No. 2 and soliciting our request for a time extension based on adverse weather conditions over the winter months.

2. In his letter, reference 1.b., contractor proposes changes that are acceptable from a technical standpoint and that appear to be reasonable in terms of net additional cost to the Government. Recommend, therefore, that subject contract be modified as follows:

a. Statement of Work. - In Section 2 - DESCRIPTION OF WORK:

(1) Change paragraph 1.1.1.3 to read as follows:

"1.1.1.3 Install 2 1/2" thick rigid insulation board with minimum thermal "R" value of 19. The 2 1/2" thickness shall consist of a single layer. Modify flashings to accommodate the insulation board by adding a 1" x 6" treated wood filler, to be secured along the perimeter of the roof."

(2) Change paragraph 1.1.3.5 to read as follows:

"1.1.3.5 In the 2" recessions on the roof deck, apply one layer of rigid insulating board to level off the roof surface."

(3) Change paragraph 1.1.3.6 to read as follows:

"1.1.3.6 Install one course of rigid styrene insulation board over the leveled roof deck. Insulation shall be applied to hot asphalt mopping over previously leveled roof deck. Install one course of 1/2" thick rigid fiberboard insulating panels over the course of styrene insulation. Fiberboard panels shall be "back-mopped" and "flopped into place."

AFZH-FEPSD-E

SUBJECT: Contract No. DAKF57-79-C-0265 (Scholten Roofing, Inc.)

b. Technical Provisions. - Delete Section 6, "Thermal Insulation for Use With Experimental Roof Systems," pages TP-6-1 and TP-6-2, and substitute attached revised Section 6, pages TP-6-1, TP-6-2 and TP-6-3, dated 20 Mar 80 (Incl 1).

3. Material Approval Submittal #2 which entails Shop Drawings and Material Listing for the EPDM roofing membrane to be installed on Area "A," the urethane foam to be installed on Area "B", and the Irathane coatings and granules to be installed, as well, on Area "B", is returned disapproved, (Incl 2). Submittal has been annotated to reflect basis for disapproval of the respective items.

4. Additional submittals required are as follows:

a. Corrections and additional data associated with our comments made in response to Material Approval Submittal #2.

b. In respect to Roof Area "C", and upon acceptance of proposed contract modification, paragraph 2, above, contractor shall be required to submit detail and installation drawings for the newly specified styrene rigid foam insulation system, including the 1/2" thick rigid fiberboard to be placed over the foam insulation system. Technical information concerning the products proposed must include an evaluation of the "R" value of the thermal insulation we may expect to attain on Roof Area "C".

5. Due to inclement weather, contractor was forced to close down his construction operation in early November 1979. Recommend, therefore, that contract completion date be extended thru 20 June 1980. Proposed length of time extension allows for a desired resume work date of 14 Apr 80 and takes into account the number of fair-weather days contractor had to work with last fall prior to complete shut down of his operations.

6. Request that a supplemental pre-construction conference be held approximately two weeks prior to the contractor resuming his work under provisions of subject contract. A principal and the foreman of the contracting company are requested to be present as well as representatives of DFAE, Ft. Lewis, and the Contracting Office. This meeting is especially necessary to establish a working relationship between the contractor and representative(s) of the Army's Construction Engineering Research Laboratory (CERL) with whom DFAE, Ft. Lewis is collaborating on the experimental aspects of subject contract work.

7. Further request that you inquire as to contractor's progress in fitting his asphalt kettle(s) with acceptable continuous temperature recording devices as required by the specifications. Lack of this feature was cause for delays in performing some of the earlier work and should be avoided in the future.

AFZH-FEPSD-E

SUBJECT: Contract No. DAFK57-79-C-0265 (Scholten Roofing, Inc.)

8. As a result of proposed contract modification, contract amount will increase by an estimated \$1,530.00. This amount coincides with contractor's proposed increase as stated in his letter, reference 1.a. Said proposal is reasonable and acceptable. FY79 P200000 funds are applicable and availability thereof will be certified by the Installation Finance and Accounting Office. Cost code is KRT5.

2 Incl
as

C. J. ALLAIRE
Colonel, CE
Facilities Engineer

Adv CF: Contracting Office, w/Incl

cc: FEW
FEB
FEM
FEE Inspection

AFZH-DRMF

TO Contracting Office

FROM FEAO

DATE

CMT 2

1. FY79 funds in amount of \$1,530.00 are _____ are not _____ available under Cost Code KRT5.

2.

SECTION 6

THERMAL INSULATION FOR USE WITH EXPERIMENTAL ROOF SYSTEMS

1. APPLICABLE PUBLICATIONS. - The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the reference thereto.

1.1 American Society for Testing and Materials (ASTM) Publications. -

C 726	Mineral Fiber Roof Insulation Board
C 208	Insulating Board (Cellulosic Fiber) (Structural & Decorative)
D 312	Asphalt Used for Roofing
D 2822	Asphalt Roof Cement
C 1177	Guarded Hot Plate
D 1621	Rigid Cellular Plastics
C 355	Water Vapor Transmission
C 209	Structural Insulating Board from Vegetable Fibers
C 272	Structural Sandwich Construction

1.2 Federal Specifications. -

HH-I-524B	Insulation Board, Thermal (Polystyrene)
-----------	--------------------------------------------

2. RIGID BOARD INSULATION used only in Area "A" under the single ply elastomeric roofing (EPDM) and under the built-up roofing in Area "C" shall be inorganic, closed cell, fiber and binder rigid board stock and shall have the following physical characteristics unless otherwise stated in these specifications:

2.1 RIGID INSULATION BOARD STOCK - REQUIRED PHYSICAL CHARACTERISTICS

<u>Characteristic</u>	<u>Test Method</u>	<u>Properties</u>
Thermal Insulation "K" Factor	ASTM C 177	0.15 (Maximum)
Compressive Strength	ASTM D 1621	25 p.s.i. (Minimum)
Moisture Vapor Transmission	ASTM C 355	25 perm In. (Maximum)
Water Absorption	ASTM C 209	2.0% by volume (Maximum)

SPEC NO. 3529 R1
20 Mar 80

2.2 Insulation board which produces chemically toxic fumes during combustion may be rejected at the discretion of the Contracting Officer.

3. RIGID STYRENE INSULATION used in Area "C" shall be a closed cell expanded polystyrene tapered foam roof insulation board having the following physical characteristics unless otherwise stated in these specifications.

3.1 Rigid Styrene Panel Stock - Required Physical Characteristics:

<u>Characteristic</u>	<u>Test Method</u>	<u>Properties</u>
Thermal Insulation "K" Factor	ASTM C 177	0.22 (Maximum)
Compressive Strength	ASTM D 1621	23 p.s.i. (Minimum)
Moisture Vapor Transmission	ASTM C 355	1.2 perms (Maximum)
Water Absorption	ASTM C 272	2.0% (Maximum)

3.2 Rigid Styrene Insulation shall conform to the requirements of Federal Specification HH-I-524B, Type I, Class A, Modified Grade, as manufactured by "Western Insulfoam Corporation" or approved equal.

4. DELIVERY AND STORAGE OF MATERIALS. - Materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Insulation shall not be exposed to any moisture before, during or after delivery to the site. Insulation shall be stored in an enclosed building or in a trailer. Wet materials shall not be used and shall be removed from the worksite.

5. SUBMITTALS. - As specified in Section 5 - BUILT-UP ROOFING.

6. APPLICATION OF INSULATION. -

6.1 Installation Requirements. -

6.1.1 Roof Area "A". -

6.1.1.1 Insulation shall be laid in a single layer in Area "A". Units of insulation shall be laid in parallel courses parallel to the roof slope. End joints shall be staggered. Insulation shall be cut to fit neatly against adjoining surfaces. Insulation which can be readily lifted after installation is not considered to be adequately secured. Insulation pattern is illustrated in Fig. 1.

SPEC NO. 3529 R1
20 Mar 80

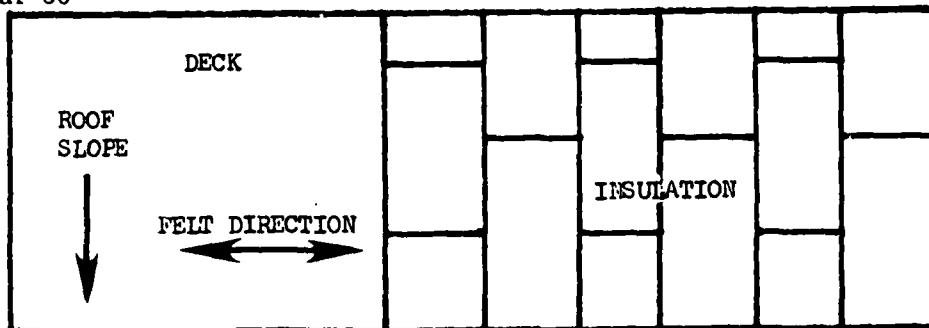


Fig. 1 - INSULATION PATTERN

6.1.1.2 Bitumen shall not be applied further than one panel length ahead of roof insulation being installed. All bare areas in concrete decks shall be primed with asphalt primer at a rate of 1 gallon per 100 square feet. All layers of insulation shall be laid in solid moppings of hot asphalt applied at the rate of 25 pounds per square maximum.

6.1.2 Roof Area "C". -

6.1.2.1 Insulation shall be laid in a single layer in Area "C". Units of insulation shall be applied strictly in accordance with instructions established by the insulation manufacturer.

6.2 Protection Requirements. - The insulation shall be kept dry at all times and shall be laid just before application of the membrane. No more insulation shall be laid than can be covered the same day with the complete roofing system. Exposed edges of the insulation shall be protected by cutoffs at the end of each day's work or whenever precipitation is imminent. Cutoffs shall be specified in Sections 3 and 5. Cutoffs shall be removed when work is resumed.

6.2.1 Storage facilities for rigid insulation board shall be provided by the contractor at a site adjacent to the work site to be designated by the Contracting Officer.

AFZH-FEPSD-E

THRU PEAO (Acct Br)
Contracting Office

Modification No. 4 to Contract DAKF57-79-C-0265, Experimental Reroofing of Post Stockade, Bldg 1450, Ft. Lewis, WA

DFAE
Mr. Leonard/Mrs. Rankin/md/5025

1. Reference Contract No. DAKF57-79-C-0265, Experimental Reroofing of Post Stockade, Bldg 1450, Ft. Lewis, WA (Spec No. 3529 R1) (IJOB B00098-9J).
2. Pursuant to agreements reached between representatives of Contracting Office, DFAE, and the contractor, in conference at the Contracting Office on 29 May 80, DFAE requests the following contract modifications.

a. PART I - STATEMENT OF WORK

SECTION 2 - DESCRIPTION OF WORK

(1) Add new paragraph:

"1.1.3.9 Elevate the mechanical roof ventilation support curb approximately 6-1/2" utilizing treated wood 2" stock. Work includes extending the sheet metal ducting to the new ventilator position. Final re-connection of electric will be accomplished by others."

(2) Add new paragraph:

"1.1.3.10 Furnish and install approximately 275 linear feet of 1" nominal thick beveled treated wood board inside of eave perimeter nailer on south, east and north sides of roof."

(3) Delete paragraph 1.1.2.1 and insert instead:

"1.1.2.1 Remove existing roofing, flashing and insulation down to existing vapor barrier. Preserve existing gravel stop aluminum flashing (3 sides) for re-use, and furnish and install new 16 oz. copper earthquake bellows flashing to match existing. Inspect existing wood eave coping block for acceptability for re-use."

(4) Delete paragraph 1.1.2.3.

(5) Delete paragraph 1.1.2.4 and insert instead:

"1.1.2.4 Prime existing vapor barrier surface and spray or foam in place urethane foam to a thickness adequate to provide a thermal insulation resistance of R-19."

(6) Renumber paragraphs to read 1.1.2.1 through 1.1.2.6.

AFZH-FEPSD-E

SUBJECT: Modification No. 4 to Contract DAKF57-79-C-2065, Experimental
Reroofing of Post Stockade, Bldg 1450, Ft. Lewis, WA

(7) Delete paragraph 1.1.3.1 and insert instead:

"1.1.3.1 Remove existing built-up roofing and gravel, remove and salvage eave gravel stop aluminum flashing to allow reroofing and re-use of the flashing. Remove reglet flashing and counter-flashing at wall along 2d story portion of the building. Inspect all treated wood eave coping blocking for acceptability for re-use. Furnish and install new 16 oz. copper earthquake joint flashing between areas B and C."

(8) Delete paragraph 1.1.3.2 and insert instead:

"1.1.3.2 Remove concrete fill on basic roof deck and from around reinforce bars protruding from slab below and along building edges and interior column areas. In addition, remove two layers of rigid insulation board below the concrete fill (Note: The concrete fill material varies in thickness from 1" to 9".)"

(9) Add paragraph 1.1.3.11 as follows:

"1.1.3.11 Contractor may wait for optimum weather to place the mineral surface cap sheet over the sub-plys of roofing felt."

b. SECTION 2 - DESCRIPTION OF NEW EXPERIMENTAL ROOF SYSTEMS

(1) Page TP-2-1, paragraph 1.2.1 Delete and add new paragraph as follows:

"1.2.1 Vapor Barrier. - In areas where existing vapor barrier has been interrupted, the vapor barrier is to be applied directly to the primed concrete roof deck after priming the concrete surfaces. It shall consist of an asphalt saturated and coated inorganic felt; coated base sheet (No. 43) Type I (plain) per ASTM Specification D-2626. The vapor barrier sheet shall be uniformly mopped to the deck with hot asphalt at 25 pounds per square and then top-coated with an additional mopping of hot asphalt at the same rate (refer to TECHNICAL PROVISIONS, Section 7). The existing vapor barrier shall be cleaned of all non-firmly attached traces of existing insulation and shall be prime coated as recommended by the foam manufacturer. Prior to prime coating existing vapor barrier, effect all necessary repairs to visible defects in the existing vapor barrier."

c. SECTION 7 - VAPOR BARRIERS

Page TP-7-1, paragraph 1. Change sentence to read as follows:

"1. VAPOR BARRIER shall be applied to roofing areas "A", "B" and portions of "C" as specified elsewhere."

AFZH-FEPSD-E

SUBJECT: Modification No. 4 to Contract DAKF57-79-C-0265, Experimental
Reroofing of Post Stockade, Bldg 1450, Ft. Lewis, WA

3. The proposed modification is required to adapt project design to accommodate as-built site conditions not readily identifiable prior to commencement of contractor's demolition work.

4. This proposed modification will result in an estimated net increase to contract cost as follows: (The figures were presented at the referenced meeting by the contractor and are the contractor's preliminary estimated amounts.)

a. Raise ventilators, Statement of Work, paragraph 1.1.3.9	\$500 additional
b. Place treated bevel board, Statement of Work, paragraph 1.1.3.10	\$700 additional
c. Furnish and install copper earthquake joint flashing, Statement of Work, paragraphs 1.1.2.1 and 1.1.3.1	\$265 additional
d. Extra work due to rebar sticking up, Statement of Work, paragraph 1.1.3.2	<u>\$4,000</u> additional
	\$5,465 additional
e. Less: savings to Government, Statement of Work, delete paragraph 1.1.2.3, Vapor Barrier	- <u>\$2,000</u> less
Total estimated increase	\$3,465

5. At the referenced meeting, the contractor agreed he would provide cost information to support his estimated quotes and, if accepted, pursue no other claims for work undertaken prior to the meeting.

6. FY79 funds in amount of \$3,465.00 are applicable and availability thereof will be certified by the Installation Finance and Accounting Office. Cost code: KRT5.

C. J. ALLAIRE
Colonel, CE
Facilities Engineer

CF:
Seattle Dist, Corps of Engr
ATTN: Mr. Collie

cc: FEB FEW
FEE Inspec FEM

ASFH-DRMF

SUBJECT: Modification No. 4 to Contract DAKF57-79-C-0265, Experimental
Reroofing of Post Stockade, Bldg 1450, Ft. Lewis, WA

TO Contracting Office

FROM FEASO

DATE

CMT 2

1. FY79 funds in amount of \$3,465 are ____ are not ____ available under Cost
Code KRT5.

2.

FORT BENNING, GEORGIA

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<u>SECTION NO.</u>	<u>SECTION TITLE</u>	<u>PAGE NO.</u>
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	<u>DIVISION 2 - SITE WORK</u>	
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2N	Environment Protection	OMIT
	<u>DIVISIONS 3 - 5</u>	OMIT
	<u>DIVISION 6 - CARPENTRY</u>	
6A	Carpentry and Miscellaneous Work	6A-1 thru 6A-5
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7C	Thermal Insulation for Built-up Roofing	7C-1 thru 7C-6
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TECHNICAL PROVISIONS
SECTION 6A
CARPENTRY AND MISCELLANEOUS WORK

.01 SCOPE: The work covered by this section of the specification consists of furnishing all plant, labor, supplies and materials, and performing all operations in connection with the installation of the rough and finished carpentry, including millwork and miscellaneous work, complete, subject to the terms and conditions of the contract, and in strict accordance with this section of the specifications and applicable drawings.

.02 APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

a. Federal Specifications:

FF-B-561c	Bolt, (Screw), Lag.
FF-B-575c	Bolt, Hexagon and Square.
FF-B-588c(1)	Bolt, Toggle and Expansion Sleeve, Screw.
FF-M-105b & Int Am-4	Nails, Wire, Brads, and Staples
FF-S-111d	Screw, Wood
FF-S-325 & Int Am-3	Shield, Expansion; Nail, Expansion, and Nail Drive Screw (Devices, Anchoring, Masonry).
MM-L-751h	Lumber; Softwood
SS-L-30d & Int Am-3	Lath, Sheathing and Wallboard; Gypsum
TT-W-571j	Wood Preservative, Treating Practices.

b. American Society for Testing and Materials (ASTM):

C 36-78	Specification for Gypsum Wallboard
C 514-77	Nails for the Application of Gypsum Wallboard

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c. National Woodwork Manufacturers Association (NWMA) Industry Standards:

NWMA 1.S.1-74 Wood Flush Doors
& Addendum

NWMA 1.S.5-73 Ponderosa Pine Doors
& Addendum

d. U. S. Department of Commerce Simplified Practice Recommendations:

R 16-53 American Lumber Standards for Softwood Lumber

e. American Institute of Timber Construction (AITC) Publication:

Timber Construction Standards, Edition, 1972.

f. National Board of Fire Underwriters Publications:

National Building Code (Current Edition).

.03 MEASUREMENTS AND SITE CONDITIONS: The Contractor shall verify all measurements at the building site and shall be responsible for dimensions, fittings, and the proper installation of items directly connected with the work. The contract drawings indicate the extent and general requirements of the work, together with typical details pertaining thereto. The contractor shall vary the installation, if need be, as required to meet the existing conditions. If such departures from the contract drawings are deemed necessary by the Contractor, details of such departures and reasons therefore shall be submitted as soon as practicable to the Contracting Officer for approval.

.04 LUMBER: a. Grade, Size and Pattern: Lumber shall conform to Federal Specification MM-L-751. Lumber shall be surfaced four sides, and worked to such patterns as are indicated or specified. Finished sizes shall conform to yard size standards of American Lumber Standards Simplified Practice Recommendation R-16 as issued by the U. S. Department of Commerce. Worked material, except as otherwise required, shall conform to American Lumber Standard patterns. All lumber shall be dressed.

b. Grade Marking: Each piece of framing and board lumber shall bear the official trademarks and grademark of the manufacturer's association or the authorized inspection bureau under rules of which the lumber is manufactured, graded, and purchased. Other lumber shall be grademarked by such association, inspection bureau, or other agency approved as competent by

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the American Lumber Standards Committee in conformity with Department of Commerce Simplified Practice Recommendation R-16. Each piece of southern pine lumber including but not limited to framing, sheathing, siding, finish, etc., shall bear the grademark of the Southern Pine Inspection Bureau at the time of delivery to the site of the work.

c. Moisture Content: Lumber to be incorporated in the structure shall conform to the moisture content requirements of Federal Specification MM-L-751. Lumber treated with water-borne preservatives shall be dried to a moisture content not exceeding 19 percent by either kiln or air drying procedures. Lumber shall be dried to a moisture content not exceeding 15 percent for kiln dried or 19 percent air dried.

d. Storage: Lumber delivered to the site shall be stored in a building or carefully piled off the ground in such a manner as to insure proper drainage, ventilating, and protection from the weather. Finish lumber shall be stored inside a building.

e. Grade, Use, and Species: Framing lumber shall be No. 2 dimension Southern Pine.

.05 PRESERVATIVE TREATMENTS: Treated materials cut after treatment shall have such surfaces well brush coated with the preservative used in the treatment.

a. Applicable Items: All lumber shall be pressure-preservative treated in a closed retort in accordance with Federal Specification TT-W-571, and the Manual of Recommended Practice of the American Wood Preservers Association.

b. Detailed Criteria: Any of the preservatives specified may be used except that coal-tar creosote or creosote solutions shall not be used. Wood treated with oil-borne preservatives shall be clean, free from surface oil, and shall be properly seasoned for use in building construction. Wood treated with water-borne preservatives shall be air-dried or kiln-dried to a moisture content not exceeding 19 percent. An affidavit signed by a member of the preservative treatment company shall be furnished stipulating the retention obtained and certifying that for oil-borne, preservative-treated materials required to be painted or to make contact with wood to be painted, the treated material conforms to the paintability, drying-time, and surface-deposit requirements of Federal Specification TT-W-571, and for waterborne, preservative-treated materials, the moisture content upon shipment from the treating plant does not exceed 19%.

.06 MATERIALS OTHER THAN LUMBER: Anchors and Fasteners shall conform to Federal Specifications as indicated:

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(1) Bolts, nuts, studs, and rivets: FF-B-561 and FF-B-575, as applicable.

(2) Lag screws or lag bolts: FF-B-561.

(3) Toggle bolt: FF-B-588.

(4) Wood screws: FF-S-111.

(5) Nails and staples : FF-N-105.

.07 GENERAL: New work and all repair work necessary to complete the job shall be accomplished by the contractor in accordance with the applicable drawings and specifications. Work to be done under this section of the specification includes all work stated on the applicable drawings and all repair work necessary to make a complete, usable facility.

.08 MISCELLANEOUS WORK: Items of carpentry not specifically specified but made necessary by the repairs, alterations, and modifications required to complete the facilities shall be accomplished in a manner in keeping with the rest of the work.

.09 ROUGH CARPENTRY: a. Plates, caps, nailing strips, nailers and framing not otherwise specified shall be: Southern Pine No. 2. (Surfaced dry or green, used at 19% max MC.)

b. Framing shall be closely fitted, accurately set to required lines and levels, and rigidly secured in place. Joists shall be set with crown edge up. Shims shall not be used on wood.

.10 DOOR FRAMES: Door frames shall be constructed of material specified in accordance with details shown on the drawings.

.11 WOOD FLUSH DOORS shall be Standard grade in accordance with NWMA Standard 1.S.5 or Sound grade in accordance with NWMA Standard 1.S.1. Doors shall have solid core with wood block core conforming to NWMA Standard 1.S.1.

.12 GYPSUM WALLBOARD: a. General; Gypsum wallboard shall be installed where shown on the drawings. Gypsum board shall be finished with standard joint treatment suitable for painting. Gypsum board shall conform to Federal Specification SS-L-30 or ASTM C 36.

b. Application: Gypsum board shall not be installed until all backing, nailing strips and blocking are installed and approved. Wood backing shall be installed directly behind all sizes (ends and edges) of each sheet of gypsum board regardless of the size of the sheet as installed. Each sheet of gypsum board shall be nailed on all four sides (ends and edges) and at the intermediate supports. The wood backing shall

consist of existing studs and joists or new support members at 1'-4" maximum on centers and of blocking at 4'0" maximum on centers installed by the contractor. Unless otherwise indicated on drawings, 2" x 4" blocking not more than 4 feet, on centers, will be provided between studs and joists to form bearing surfaces for nailing ends and edges of gypsum board, except where ends or edges occur at center of joists or studs. Gypsum board shall be nailed not less than 3/8" from edges and ends of sheets and not more than 6" on centers. Nails at supports between edges and ends of sheets shall be not more than 8" on centers. Nails shall be 1' 1/4" plaster board nails conforming to Federal Specification FF-N-105 or ASTM C 514.

.13 Builders Hardware: Items of hardware specified herein or required to complete the job shall be incorporated in the work. Upon completion of the work, hardware shall be demonstrated to work satisfactorily.

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TECHNICAL PROVISIONS
SECTION 7C
THERMAL INSULATION FOR BUILT-UP ROOFING

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances, and materials, and in performing all operations in connection with the installation of insulation for built-up roofing, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

a. Federal Specifications:

FF-N-105B & Am-4	Nails, Brads, Staples and Spikes: Wire, Cut and Wrought
HH-1-529B	Insulation Board, Thermal (Mineral Aggregate)
HH-1-530A & Int. Am 3	Insulation Board, Thermal (Urethane)
HH-1-551E	Insulation Block and Boards, Thermal (Cellular Glass)

b. American Society for Testing and Materials (ASTM) Publications:

D 41-78	Asphalt Primer Used in Roofing, Damp-proofing and Waterproofing
D 226-77	Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs
D 2822-75	Asphalt Roof Cement
D 250-77	Asphalt-Saturated Asbestos Felts for Use in Waterproofing and in Constructing Built-Up Roofs

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D 312-78

Asphalt for Use in Constructing
Built-Up Roof Coverings

D 2626-73

Asphalt-Base Sheet for Use in
Construction of Built-Up Roofs

c. American Society of Heating, Refrigerating and Air-Conditioning
Engineers, Inc. (ASHRAE) Publication:

ASHRAE Handbook of Fundamentals (1972).

.03 GENERAL: Insulation for built-up roofing shall be applied to the roof surfaces indicated. In the application of the vapor barriers and insulation, asphalt shall be used with asphalt-saturated felts. Asphalt shall not be heated above 475 degrees F. Kettlemen shall be in attendance at all times during the heating to insure that the maximum temperature specified is not exceeded. Temperature of the bitumen at the time it is applied shall be in accordance with the insulation manufacturers recommendations. Application temperatures shall be measured at the mop bucket and/or mechanical applicator. The roof-deck surface shall be free from ice, frost, and surface moisture and shall be smooth, firm, free from dirt, projections, and foreign materials. Vents and other items penetrating the roof shall be secured in position and properly prepared for flashing. Application of materials shall not be performed under excessive wind conditions, wet conditions or when the ambient temperature is less than 40 degrees F. Method of attachment shall be in accordance with insulation manufacturer's recommendations and the requirements specified hereinafter. Insulation work shall be coordinated with roofing and sheet metalwork so that all material applied each day is water-proofed the same day with the complete roofing system and sheetmetal flashings. Wet materials shall not be used and shall be removed from the worksite. Materials shall be stored in an approved manner and shall be protected from contact with soil and from exposure to the elements. Felt rolls shall be stacked on end. For 24 hours immediately before laying, felt rolls shall be stored in an area maintained at a temperature no lower than 50 degrees F. Urethane and composite board insulation shall be stored out of direct sunlight and away from areas where welding is being performed or where contact with open flames is possible.

.04 SUBMITTALS:

a. Computations used for determining insulation thickness shall be submitted for approval.

b. Proof that composite board insulation for use on any roof deck meets the requirements of Underwriters Laboratories, Inc. or Factory Mutual Research Corporation.

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c. Samples shall be submitted as follows for Independent government testing:

Thermal Insulation Board	One full-sized section of each type.
Fasteners	One pound of each type, size and style.

.05 MATERIALS shall conform to the following requirements:

- a. Asphalt Primer: ASTM D 41.
- b. Bitumen: Asphalt: ASTM D 312, Type III.
- c. Bituminous Cement: ASTM D 2822, Type I.
- d. Insulation shall be one of the following materials:

(1) Cellular Glass: Federal Specification HH-1-551, Type IV.

(2) Composite Board Insulation: Composite board insulation shall consist of urethane board factory bonded to expanded perlite board. The top surface of the urethane board shall be covered with a layer of asphalt saturated felt or glass-fiber mat securely bonded to the urethane during manufacture. The urethane component shall conform to Federal Specification HH-1-530, type I. Composite board insulation shall be fire approved for class I steel deck construction by Factory Mutual Research Corporation or for metal roof deck constructions fire labeled by Underwriters' Laboratories, Inc.

e. Nails and Fasteners:

(1) Nails for fastening insulation to flush mounted wood nailers: Federal Specification FF-N-105, Type II, Style 20, of sufficient length to hold insulation securely in place.

(2) Fasteners:

(a) Fasteners designed to secure insulation to steel decks shall conform to the requirements of Underwriters' Laboratories, Inc., or Factory Mutual Research Corporation.

(b) Bolts and Nuts shall be semifinished or finished, threaded for medium fit with either hexagonal-shaped or square-shaped nuts and boltheads.

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(c) Metal Disks shall be flat and not less than 30 gage thicknesses, and shall be minimum 2-1/8 inch diameter.

f. Vapor-barrier Membrane: Asphalt-saturated Felt: ASTM D 226, Type I or ASTM D 250, 15-pound type.

.06 APPLICATION OF VAPOR BARRIER:

Over Concrete Decks: The bitumen applied vapor barrier shall consist of two plies of 15-pound type saturated felt, mopped on at right angles to the direction of slopes. Plies shall be lapped 19 inches and solid mopped between plies. Felt shall be laid in 15 to 25 pounds of asphalt per square. Where asphalt-saturated felts are used, asphalt primer shall be applied to the deck at the rate of 1 gallon per square over the entire surface to be mopped. Felts will be solid mopped directly to the deck. Prior to application of vapor barrier, joints in precast concrete decks shall be covered with a 4-inch strip of roofing, felt, embedded in and coated with bituminous cement. As each course of felt is mopped into hot bitumen, the felts shall be carefully broomed in with an 18 to 20-inch wide soft-fiber-type floor broom to obtain complete adhesion between plies and to eliminate air pockets. The method of mopping a half-sheet width and turning the sheet back to mop under the other half shall not be used. At eaves and rakes the two layers of vapor-barrier felts shall be extended and turned back 9 inches, or separate sheets shall be applied with not less than 9 inches on the roof deck and turned back 9 inches. The turnback shall be mopped in over the top of the vapor barrier. Bituminous plastic cement shall be used at eaves and rakes under the vapor barrier for not less than 9 inches. Vapor barrier or separate sheet shall be turned back over edges of insulation at roof penetrations and locations other than parapet walls, eaves and rakes. A glaze coat of 15 pounds per square of asphalt shall be applied. Before application of foamed in place insulation the surface shall be primed in accordance with the foam manufacturer's approved instructions.

.07 THICKNESS OF INSULATION: The drawings shall not be scaled to determine the required thickness of insulation. Actual installed thickness of insulation shall be such as to provide a coefficient of heat transmission or U-value, through the completed roof construction air-to-air, not in excess of 0.050 B.t.u. per hour, per square foot, per degree F. temperature difference, when determined for winter conditions in accordance with recognized methods in agreement with ASHRAE Handbook of Fundamentals. Roof construction air-to-air may include finish ceilings, provided unceilinged areas do not occur under the same roof area or space above the ceiling is not vented to the exterior. Insulation thickness shall be uniform over common roof areas.

.08 APPLICATION OF INSULATION: Insulation shall be laid in one or more layers. When mechanical fasteners are used for insulation installed in two or more plies both layers shall be secured with fasteners. Each layer shall be embedded in hot bitumen applied at the rate of at least 20 pounds of asphalt per square. Asphalt primer shall be applied at the rate of 1 gallon per square over the entire surface to be mopped when the insulation is applied directly to concrete deck. Units of insulation shall be laid in parallel courses with horizontal joints broken, in moderate contact with adjoining units without forcing, and cut to fit neatly against adjoining surfaces. Composite board insulation shall be laid with the urethane component up. Successive board layers shall have joints staggered with respect to joints of preceding layer. The insulation shall be kept dry at all times and shall be laid just before application of the roofing. No more insulation shall be laid than can be covered the same day with the complete roofing system. Exposed edges of the insulation shall be protected by cutoffs at the end of each day's work. Cutoffs shall be two layers of bituminous-saturated felt set in plastic bituminous cement, or as specified by the roofing manufacturer. Cutoffs shall be removed when work is resumed.

a. On Steel Decks: Insulation laid directly on the deck shall be installed using mechanical fasteners which are approved by Factory Mutual Research Corporation, in the pattern and quantity as recommended by the insulation or mechanical fastener manufacturer, except that quantity shall not be less than one fastener per two square feet of insulation.

TECHNICAL PROVISIONS
SECTION 7F1
BUILT-UP ROOFING

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances, and materials, and in performing all operations in connection with the installation of built-up roofing, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

a. American Society for Testing and Materials (ASTM) Publications:

C 208-72	Insulating Board (Cellulosic Fiber), Structural and Decorative.
D 41-78	Primer for Use with Asphalt in Dampproofing and Waterproofing.
D 226-77	Asphalt-Saturated Organic Roofing Felt for Use in Membrane Waterproofing and Built-Up Roofing.
D 312-78	Asphalt for Use in Constructing Built-Up Roof Coverings.
D 1751-73	Performed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
D 1863-77	Mineral Aggregate for use on Built-up Roofs.
D 2822-75	Asphalt Roof Cement.
D 3617-77	Sampling and Analysis of New Built-Up Roof Membranes.

.03 GENERAL: Asphalt bitumen built-up roofing shall be applied to the roof surface indicated.

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a. Delivery and Storage of Materials: Roofing materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Felts and roll roofing shall not be exposed to any moisture before, during, or after delivery to the site. Felts and roll roofing shall be stored in an enclosed building or in a trailer, stacked on end, and maintained above 50 degrees F for 24 hours immediately before laying.

b. Coordination requirements: Roofing operations shall be coordinated with sheet metal work so that flashings are installed to permit continuous roof surfacing operations the same day felts are installed. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is waterproofed the same day with the complete roofing system.

c. Preparation Requirements: Items penetrating the roof shall be secured in position and properly prepared for flashing.

d. Preparation for Reroofing: Existing roof deck shall be stripped of roofing membrane, insulation, vapor barrier, cants, embedded flashing, nails, fasteners, and deteriorated nailers. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at end of each working day.

e. Application Requirements: Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. The roofing or flashing shall be applied to a smooth and firm surface free from ice, frost, moisture, dirt, and foreign materials. Application of roofing shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40 degrees F.

f. Bituminous-plastic-type flashings installed in accordance with these specifications shall be used throughout unless otherwise specified or indicated. Metal flashings are specified in SECTION: SHEET METAL WORK.

.04 SUBMITTALS: a. Certificates of Compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the SPECIAL PROVISIONS.

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b. Manufacturers Installation Instructions shall be submitted and approved prior to delivery of materials to the site. Instructions shall specify acceptable range of bitumen application temperatures. Bitumen manufacturer shall specify maximum temperature for holding bitumen in a heated condition.

c. Temperature Control Equipment: Contractor shall submit manufacturer's literature on the automatic temperature recorder and automatic thermostatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting that the recorder, automatic temperature control, and portable thermometer were each tested immediately prior to shipment to the site and that all operate within the accuracy tolerances given in the manufacturers specifications. Temperature control and recording equipment shall be in proper working condition during use.

d. Samples: The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

Felts - 7-ft sample from end of each roll used
Bitumen - 10 pounds of each type used
Primer - 1 gallon
Bituminous cement - 1 gallon
Surfacing materials - 100 pounds
Nails, fasteners, and anchors - 1 pound of each type, size, and style

.05 MATERIALS: a. Asphalt Primer: ASTM D 41.

b. Asphalt: ASTM D 312, Type I on slopes up to and including 1/2 inch per foot.

c. Cants shall be made from treated wood or treated fiberboard and shall reduce the angle covered into two equal angles. Treated wood shall be of water-borne preservative-treated material as specified in SECTION: CARPENTRY AND MISCELLANEOUS WORK. Fiberboard shall conform to ASTM C 208 treated for moisture resistance by integral treatment with wax or other sizing or with bituminous impregnation.

d. Felt shall be the asphalt saturated type and shall conform to the following requirements: ASTM D 226, Type I.

e. Nails, Fasteners, and Anchors shall be an approved type recommended by the roofing felt manufacturer.

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f. Roofing Cement: ASTM D 2822, Type 1.

g. Aggregate for Surfacing: ASTM D 1863.

.06 ASPHALT BUILT-UP 4-PLY ORGANIC ROOFING: On Insulation Surfaces: Four plies of roofing felt shall be mopped in solid with hot asphalt. Felts shall be laid shingle-fashion at right angles to the direction of the insulation and lapped in accordance with Table 1. The flashings shall be installed and the flood coat and surfacing applied.

.07 APPLICATION OF ROOFING: a. General Requirements: The entire roofing system, including aggregate surfacing, shall be finished in one operation up to the line of termination at the end of day's work. Application of roofing shall immediately follow application of insulation as a continuous operation. Phased construction will not be permitted. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen.

b. Detailed Requirements:

(1) Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

(2) Bitumen stops formed of edge envelopes shall be installed at eaves and rakes. Envelopes shall be formed of two 18-inch wide layers of roofing felt. Nine inches of the width shall be attached to the roof surface with 9 inches extended beyond the edge. The first layer shall be applied in a 4-inch wide layer of roofing cement and nailed 1/2-inch from the top edge at 6-inch spacing. The second layer shall be applied to the first in a 9-inch wide mopping of bitumen. The free edges shall be protected from damage throughout the roofing period.

(3) Application and holding temperatures shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers. Each layer of roofing felt shall be laid in not less than 15 pounds of asphalt per square or more than 25 pounds of asphalt per square.

(4) Layers of roofing shall be laid free of wrinkles, creases or fishmouths, immediately behind the applicator. The surface of the felts shall be broomed-in full width to obtain complete adhesion between plies and to eliminate air pockets. Brooms shall have soft bristles and shall be discarded when the bitumen build-up on the fiber prevents application of equal pressure across the broom width on felts. The method of mopping a half-sheet width and turning the sheet back to mop under the other half will not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 4 inches, or to the top of the cant strip. After the last ply of roofing felt is applied, the edge envelope shall be formed by folding back and mopping each layer. The gravel stop, specified in SECTION: SHEET METALWORK, shall be embedded in bituminous cement and nailed on top of the envelope.

(5) Each course of roofing felts, in addition to being mopped in hot bitumen, shall be lapped as specified in Table 1.

(6) Nails and fasteners for securing roofing shall be flush-driven through flat metal disks of not less than 1-inch diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 1-inch diameter disks.

(7) At end of each day's work or whenever precipitation is imminent, the terminated edge of built-up roofing shall be sealed with two full width strips of felt set in bituminous cement. Cut insulation pieces shall be temporarily laid in place to straighten the exposed edge of insulation. Extend half-width of strips up and over the finished roofing and extend the other half-width out and onto the bare roof deck surface. Water cutoffs shall extend into and seal flutes in metal decks. Water cutoffs and temporary insulation pieces shall be removed before continuing installation of roof system. Extra full-width strips of felt shall be used as needed to insure complete covering of insulation.

.08 FLASHINGS: Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous-plastic-type flashings described below shall be used, except where metal flashings are indicated or specified in SECTION: SHEET METALWORK. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends.

a. Base Flashings: Materials and installation shall be in accordance with the approved recommendations of the roofing felt manufacturer. Base flashings shall consist of one ply of asbestos felt

and one ply of a reinforced asbestos flashing sheet as the outer ply. Cants shall be installed in the angles formed at walls and other vertical surfaces as backing for base flashings. Cants shall be laid in a solid coat of bituminous cement just prior to laying the roofing plies. Cants shall have 5 1/2-inch face dimension and shall be continuous and installed in lengths as long as practicable. Cants shall be mitered at all changes of direction.

b. Strip Flashings: Roof flanges of lead and sheetmetal flashings, such as gravel stops, base flashings, and plumbing flashings shall be stripped with two layers of roofing felt set in plastic cement. After installation of flanges or flashings over the top ply of roofing, the strip flashings, consisting of two layers of roofing felt, 9 and 12 inches wide, shall be successively cemented to the top of the roof flange using bituminous plastic cement, to form a waterproof joint between roofing and flashings.

c. Sleeve-Type Bitumen Stops shall be installed at all pipe and conduit roof penetrations. Sleeve shall be 3 inches high; flange shall be 3 inches wide. Flange of bitumen stop shall be placed on the insulation below the roofing membrane. Bitumen stops shall be made of stainless steel and nailed in place as specified in SECTION: SHEET METALWORK.

d. Bitumen Pockets shall be installed on top of the roofing membrane at all irregularly shaped roof penetrations, and at pipe and conduit penetrations which cannot be flashed with sleeve-type bitumen stops. Bitumen pocket shall be 3 inches high; flange shall be 4 inches wide. Flange shall be set in plastic cement, and nailed as specified in SECTION: SHEET METALWORK. Pocket shall be filled with 1 inch of plastic cement and 2 inches of bitumen. After bitumen has cooled, a tapered layer of plastic cement shall be applied and trowelled smooth.

.09 SURFACING: Contractor shall determine the moisture content of a representative sample of the surfacing material. If materials are found with excessive moisture contents, the material shall be dried on the site to meet ASTM D 1863 specifications. After roofing felts have been laid and flashings installed, the roof surface, except for cants, shall be flood-coated uniformly with 60 pounds of asphalt per square. While bitumen is still hot, 400 pounds per square of roofing aggregate shall be embedded therein. Aggregate shall be placed in the manner and quantity required to form a compact embedded overlay. Roof surface shall be swept and all loose aggregate removed. Flood coat and aggregate shall be applied the same day as the felts are laid. If there is a probability of rain falling on the felts before the flood coat and aggregate can be applied, a light glaze coat of bitumen, 10 to 15 pounds per square, shall be applied over the exposed felts. The glaze

coat may be considered as part of the flood coat provided the surfacing operation is completed within 48 hours after application of the glaze coat. Where glaze coat is used, surface treatment shall be completed as soon as weather conditions permit.

.10 QUALITY ASSURANCE: a. Reverification of Temperature Controls: Contractor shall verify the accuracy of the temperature recorder each work day before using bitumen from kettle or tanker, using a portable thermometer.

b. Charts and Records: Contractor shall provide daily the chart from the temperature recorder and evidence that the recorder accuracy was verified.

c. Application Temperatures: Contractor shall furnish a daily record indicating the application temperature of each bucket of bitumen accepted on the roof.

d. Roof Cutout Samples: Roof sampling shall comply with ASTM D 3617 except that one sample shall be taken for each 10 squares (1000 square feet) of roofing, and also as directed by the Contracting Officer when there is reason to believe that deficiencies exist. Sample dimensions shall be 4 inches by 36 inches. Length of sample shall be taken across the felts. The Government will test the sample for head laps, weight, free water, and existence of voids. The hole in the roofing membrane shall be flooded with hot bitumen and a new section of equivalent size and structure shall be built in the hole. The sample area shall be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the sample area 3 inches on all sides and each succeeding ply overlapping the preceding 3 inches on all sides. If the sample indicates a deficiency, the Contractor shall take additional samples to determine the extent of the deficiency. Deficient roofing shall be removed and replaced. A sample shall be taken from replaced roofing.

.11 PROTECTION: The Contractor shall take all precautions to protect the interiors of the buildings during his operations and shall provide necessary protective covering when needed. Care shall be exercised to prevent damage to any appurtenances attached to the buildings. Any damage incurred to such appurtenances during the reroofing shall be repaired or replaced by the Contractor without cost to the Government. The Government reserves the right to stop the contractor from removing existing roofing from buildings when rain is threatening until all roof areas uncovered are made watertight. No building will be left without a roof at the end of a working day.

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TABLE I
LAPS FOR ROOFING FELTS AND ROLL ROOFING (a)

Layers or piles	Laps in inches for 36-inch width	Starting widths in inches for 36-inch width
4	27-1/2	9, 18, 27, and 36

(a) End laps of roofing felts shall be not less than 6 inches and shall be staggered a minimum of 12 inches.

TECHNICAL PROVISIONS
SECTION 7F3
ELASTOMERIC ROOFING (EPDM)

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances, and materials, and in performing all operations in connection with the installation of elastomeric roofing, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

American Society for Testing and Materials (ASTM):

D 3253-77	Vulcanized Rubber Sheetting for Pond, Canal and Reservoir Linings.
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.03 GENERAL: Bonded Ethylene Propylene Diene Monomer (EPDM) roofing shall be applied to the roof surfaces indicated. Roofing membrane shall be furnished in the largest sheets possible to minimize joints. All materials used for the roofing system shall be the products of a single manufacturer. Membrane shall be free of any pinholes, lumps and foreign material.

a. Standard Product: The EPDM roofing system including flashing shall be the standard product of a single manufacturer regularly engaged in the production of this type of product.

b. Delivery and Storage: Materials shall be delivered to the job site in the manufacturer's original, unopened packages, clearly marked with the manufacturer's name, brand name, and description of content. Materials shall be stored by contractor in clean, dry areas at a temperature between 60 degrees F and 80 degrees F.

c. Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous-roof surfacing operations. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is weatherproofed the same day with the completed roofing system.

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d. Preparation for Reroofing: Existing roof deck shall be stripped of roofing system, insulation, vapor barrier and cants. Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roofing membrane. All debris shall be removed from the roofing using a covered chute or other device to minimize the spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made to renew such surfaces at the contractor's expense. Ground area around the chute shall be cleaned immediately after completion of stripping activities. Stripping shall be limited to area to be reroofed during the same day. Roofs shall be completely weatherproofed at the end of each working day.

.04 SUBMITTALS: Contractor shall submit the following in accordance with the SPECIAL PROVISIONS.

a. Certificate of Compliance attesting that the materials meet specification requirements.

b. Qualifications of Installer: Certificate from manufacturer identifying the installer and certifying that the installer is qualified to install the roofing system.

c. Manufacturer's Instructions for installation of the membrane, including procedures for preparing the membrane for use, flashing, splicing, and bonding of the membrane.

d. Samples of Membrane Materials and Aggregate shall be submitted for testing by the Government. A 1-ft wide, full width sample shall be furnished from the end of each piece of EPDM membrane placed on the roof. In addition, 200 square feet of representative samples of the EPDM membrane used shall be furnished. An 18-inch long by 12-inch wide sample of the seam formed by connecting adjacent sheets of EPDM membrane shall be furnished from the first 100 feet of seam constructed plus an additional sample the same size from each additional 300 feet of seam constructed. In addition, 20 feet of seam 1-ft wide formed by connecting two sheets of EPDM shall be furnished. One quart of each bonding adhesive, one cartridge of sealant and 1 lb. of fasteners shall also be furnished.

e. Shop Drawings showing roof plan with dimensions, size of sheets, position of sheets and splices, nailing of sheets, flashing details, location and types of penetration, and special details.

.05 MATERIALS: a. Nonreinforced EPDM: Membrane shall be .060 inch thick, and shall comply with ASTM D 3253, Type II, except as follows:

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<u>PROPERTY</u>	<u>VALUE</u>
Tensile Strength	1400 psi min
Tear Resistance	125 lb/in min
Heat Aging (Accelerated) Elongation Retention	210% min
Brittleness	-50°F min
Ozone Resistance	No Cracks
Water Vapor Permeability	2.0 perm-mils

b. Adhesives: Cements and sealants shall be of types recommended by the roofing membrane manufacturer.

c. Wood nailers shall be number 2 or better grade lumber and shall be water-borne preservative treated.

d. Insulation shall be board insulation as specified in SECTION: THERMAL INSULATION FOR BUILT-UP ROOFING and shall be approved as compatible with the elastomeric roofing system by the manufacturer.

e. Fasteners: Nails and fasteners used with flashing, nailers, and insulation shall be of the types and sizes best suited for the job and shall comply with roofing manufacturer's approved instructions.

f. Flashing shall be of durable elastomeric material compatible with the membrane specified, as furnished by the roofing manufacturer.

g. Prefabricated Accessories shall be of types and sizes recommended by the roofing membrane manufacturer.

.06 INSTALLATION: Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

a. Nailers shall be installed on the perimeter of roof surfaces, curb flashing, and similar penetrations. Nailers shall be firmly anchored to resist a force of 75 pounds per linear foot. The top of nailer shall be flush with surface to which membrane is applied.

b. Insulation shall be placed completely covering the roof. Insulation shall be mechanically fastened in accordance with SECTION: THERMAL INSULATION FOR BUILT-UP ROOFING. Mechanical fasteners used to hold insulation in place shall be covered with 30 pound roofing felt adhered in place.

c. Membrane shall be fastened in place and sealed to adjoining sheets using minimum 3 inch wide laps. Direction of lap shall be such that water flows over the lap. Membrane shall be installed free of wrinkles.

d. Splices: Mating surfaces shall be cleaned with heptane, or with unleaded or white gasoline. Splice edges shall be cleaned of adhesive with solvents and sealed.

e. Nailing: Membrane shall be mechanically fastened to all nailers using roofing nails.

f. Flashing: All projections and changes in roof planes shall be flashed. The splice between the flashing and the main roof sheet shall be completed before bonding the flashing to the vertical surface. The splice shall be sealed a minimum of 3 inches beyond the fasteners which attach the membrane to the horizontal nailer. The installed flashing shall be nailed at the top of the flashing a maximum of 12 inches on center under the metal counter-flashing or cap.

g. Cut-offs: If work is terminated prior to weatherproofing the roof, the insulation line shall be straightened using loose-laid cut sheets and the membrane shall be sealed to the roof deck. Flutes in metal decking shall be sealed off along the cut-off edge. Membrane shall be pulled free or cut to expose the insulation when resuming work and cut insulation sheets used for fill-in shall be removed.

.07. Inspection: All joints shall be inspected over entire length after completion and all defective areas resealed. Damaged areas of membrane shall be removed and recovered, lapping underlying membrane by at least 3 inches on all sides. The roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications. Contractor shall submit the certificate to the Contracting Officer.

TECHNICAL PROVISIONS
SECTION 7F4
ELASTOMERIC ROOFING, FLUID APPLIED

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances, and materials, and in performing all operations in connection with fluid applied elastomeric roofing, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

a. American Society for Testing and Materials (ASTM) Publications:

C 177-76	Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate
C 728 72	Perlite Thermal Insulation Board
D 1621-73	Compressive Properties of Rigid Cellular Plastics
D 1622-63	Apparent Density of Rigid Cellular Plastics
E 96-66 (R1972)	Water Vapor Transmission of Materials in Sheet Form

b. Factory Mutual Corporation (FM) Publications:

Approval Guide, Equipment, Materials, Services for Conservation of Property

c. Underwriters Laboratories, Inc. Publications:

UL 790	Tests for Fire Resistance of Roof Covering Materials
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d. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. (ASHRAE) Publication:

ASHRAE Handbook of Fundamentals (1972)

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.03 GENERAL: The roofing system shall consist of a vapor barrier and a layer of sprayed-in-place urethane foam roof insulation covered with a two-coat elastomeric coating. The system shall be applied to the roof surfaces indicated.

a. Delivery and Storage: Materials shall be delivered to the job site in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials shall be stored in clean and dry areas.

b. Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations.

c. Preparation: Surfaces shall be dry and free of loose coatings or other contaminants. Workmen shall wear clean, soft-soled sneaker-type shoes.

d. Preparation for Reroofing:

(1) Removal: Debris from existing roof shall be removed using a covered chute or other device to minimize spread of dust and debris. Existing surfaces shall be protected from damage; repairs shall be made at contractor's expense. Ground around chute shall be cleaned immediately after completion of removal activities.

(2) Cleaning: Prepared roof area shall be cleaned with compressed air using three passes, each at a right angle to the preceding one. Last pass shall be made immediately prior to application of new roofing system. Debris accumulated shall be dumped down the chute. Contractor shall prevent the loss of debris around the perimeter of the building.

(3) Protection: The roof shall be completely weatherproofed at the end of each work day. Removal activities shall be limited to that area which can be reroofed during the same day.

(4) Stripping: Existing roof deck shall be stripped of roofing system, insulation, vapor barrier, and cants. Surface shall be cleaned.

(5) Vapor barrier shall be as specified in the SECTION: THERMAL INSULATION FOR BUILT-UP ROOFING.

(6) Priming: After cleaning, roof surfaces shall be primed at an application rate recommended by the roofing manufacturer.

e. Over-Spraying: Contractor shall construct barriers or take other measures to prevent overspraying and shall be responsible for damages resulting from overspraying.

.04 SUBMITTALS: The following shall be submitted in accordance with the SPECIAL PROVISIONS:

a. Certificates of Compliance attesting that the materials meet the specification requirements, and certificate from coating manufacturer certifying that coating and foam system being supplied has been tested and meets the requirements of UL 790.

b. Qualifications of Installer: Certificate from the foam and coating manufacturers identifying the installer and certifying that the installer is qualified to install the roofing system.

c. Manufacturer's Instructions for installation of the foam and coating roofing system.

d. Certificate from Manufacturer showing required thickness to obtain required U-value.

e. Samples shall be submitted as follows for independent Government testing:

Each component of foam and protective coating	5 gallon container
Thermal insulation board	one 4 by 4 foot section
Granules	10 pounds
Primer	1 gallon
Sealant	1 cartridge
Foam with coating	6 samples (2 ft x 2 ft)
Completed roofing system including wearing course	2 samples (2 ft x 2 ft)

.05 MATERIALS: a. Urethane foam: Cured foam shall conform to the following properties:

<u>PROPERTY</u>	<u>TEST METHOD</u>	<u>VALUE</u>
Density, lb/ft ³ overall	ASTM D 1622	2.7 min., 3.5 max.
Compressive strength psi parallel to rise	ASTM D 1621	40.0 min.
Thermal Conductivity (K factor) Btu/hr/ft ² /°F/min	ASTM C 177	new 0.11 max. aged 0.15 max.

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b. Protective Coating System shall be one of the following permeable types with a maximum perm rating of 3.5 when tested as specified in ASTM E 96, procedure B.

(1) Silicone weather coating, manufactured by General Electric Company (medium gray base coat SCM 3308/501C and cement gray top coat SCM 3304/3307C).

(2) Silicone 3-5000 construction coating manufactured by Dow Corning Company (light gray base coat and white top coat).

(3) Catalyzed urethane, IRATHANE Weather/Flex Plus manufactured by Irathane Systems (urethane base coat of IRATHANE 300 and a hypalon top coat of IRATHANE 157).

c. Granules: No. 11 screen size, ceramic coated, in colors provided by the manufacturer.

d. Primer and Sealer shall be of the type recommended by the coating manufacturer.

.06 INSTALLATION: Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

a. Urethane Foam shall be sprayed on the vapor barrier to a minimum thickness to obtain required U-value except where variations are needed to ensure drainage. Foam shall be applied in 1/2 inch lifts. Time between lifts shall not exceed 4 hours. The finished surface shall be smooth and free of voids, crevices, and pinholes. Foam with surface conditions known as "tree bark" or "popcorn" shall be removed and replaced at the contractor's expense. Foam shall be extended up walls and around roof projections to form cants and flashings that terminate at least 2 inches above finished roof surface. Foam shall be cured and free from water, dust, oils, and other materials which would impair adhesion of coating. No foam shall be allowed to stand overnight without a base protective coating. Foam shall cure at least one hour before application of protective coating.

b. Thickness of foam insulation shown on the drawings is not to scale; actual installed thickness shall be such as to provide a coefficient of heat transmission or U-value, through the completed roof construction air-to-air, not in excess of 0.050 BTU per hour, per square foot, per degree F. temperature difference, when determined for winter conditions in accordance with recognized methods in agreement with ASHRAE Handbook of Fundamentals. Roof construction air-to-air may include finished ceilings provided unceilinged areas do not occur under the same roof area. Computations to determine minimum required thickness shall be approved.

c. Protective Coating: Coatings shall be applied and cured in accordance with manufacturer's instructions. Coating shall consist of a base coat and top coat. Base coats exposed for more than 24 hours shall be cleaned with a detergent solution, rinsed thoroughly, allowed to dry, and recovered with base coating.

(1) Base coat shall have a minimum dry thickness of 10 mils for silicone, or 15 mils for Irathane. Coating shall completely cover the foam and extend up vertical surfaces 2 inches beyond foam. Coating shall be dry and clean before application of top coat.

(2) Top coat shall be applied at right angles to the direction of base coat application. Total dry film thickness shall be 20 mils minimum. Film thickness shall be verified by taking samples as specified below. Sample areas shall be recoated to restore film. Foam with "orange peel" or "coarse orange peel" surfaces shall have additional coating applied as required to obtain minimum dry film thickness.

d. Flashing: Areas to be flashed shall be dry and free from all dust, dirt, tar, oils, and other debris. Metal surfaces shall also be free from all rust. Termination points requiring flashing shall be caulked with manufacturer's recommended sealant. Coating shall then be applied at a rate of 1 gallon per 100 square feet to an area a minimum of 4 inches on either side of the sealant. After flashing system has cured, 2 additional coats shall be applied to flashing areas during normal coating operations.

e. Granules: Granules shall be applied within 5 minutes of top coat application, using pressure equipment, at a rate of 50 lbs per 100 square feet. Granules shall be applied in a minimum of 2 passes at right angles. Finished granule system shall be uniform over entire surface with no apparent void areas. No traffic shall be allowed on finished area for 24 hours after granule application is completed.

.07 EQUIPMENT CALIBRATION: Spray equipment for two-component system shall be calibrated each day at start of operations, each restart if spraying operations have been terminated for more than one hour, if there is a change in fan pattern, change in pressure, slow curing areas are noticed, change in work area requiring a change in hose length or in working height, after changing or cleaning filter elements, after changing curing agents, after changing between protective coatings, and whenever a malfunction is suspected. Calibration shall consist of demonstrating that the equipment is adjusted to deliver components in the proportion and at rate specified in approved manufacturer's instructions. Calibration tests shall be accomplished on the roof adjacent to the area to be sprayed.

.08 CONTROL SAMPLES: Immediately following satisfactory completion of each calibration procedure, the contractor shall collect the samples specified below. The date, time of day, and material identification of each sample layer shall be clearly marked.

a. Foam: Contractor shall prepare wooden open-top boxes 24 inches square by depth of finished roof section. Boxes shall be filled in 1/2-inch lifts during actual roof foaming, each lift being collected at the same time it is applied to the roof.

b. Protective Coating: Samples shall be collected after each calibration and at least once per ten squares of application in a continuous operation. Contractor shall place two Government furnished test plates in path of spray operations, remove them after being sprayed, and respray areas to repair coating. Wet thickness shall be determined from one plate; if deficient the contractor shall be directed to take corrective action. The 24-inch square foam samples shall be coated in the same manner.

.09 INSPECTION: Foam surface will be inspected for texture, blisters, non-adherence to substrate, and other defects before finish coating is applied. All pinholes shall be finished flush with the sealant recommended by the coating manufacturer. Roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications.

TECHNICAL PROVISIONS
SECTION 7G
SHEET METAL WORK

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances, and materials, and in performing all operations in connection with the installation of sheet metal work, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

a. Federal Specifications:

O-F-506c	Flux, Soldering; Paste and Liquid.
QQ-S-571E & int. Am-2	Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy.
SS-C-153C	Cement; Bituminous, Plastic.
TT-P-645	Primer, Paint, Zinc-Chromate, Alkyd Type.
TT-S-00230c(2)	Sealing Compound, Elastomeric Type, Single Component.
TT-S-001543a	Sealing Compound, Silicone Rubber Base.
TT-S-001657	Sealing Compound, Single-Component, Butyl Rubber Based, Solvent Release Type

b. American Society for Testing and Materials Publications:

B 209-78	Aluminum-Alloy Sheet and Plate.
B 211-75	Aluminum-Alloy Bars, Rods, and Wire.
B 221-76	Aluminum-Alloy Extruded Bars, Rods, Shapes and Tubes.

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B 316-75	Aluminum Alloy Rivet and Cold Heading Wire and Rods.
D 226-77	Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs.
D 822-60 (1973)	Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer and Related Products.
D 1784-78	Rigid Poly (Vinyl Chloride) and Poly-1, 2-Dichloroethylene Compounds

.03 GENERAL: Sheet metal items shall be fabricated to the thickness or weight shown in Table I and multiple lengths of items shall be joined together as shown in Table II. Surfaces that are to receive sheet metal and underlayments shall be even, smooth, sound, thoroughly clean and dry, and free from defects that might affect the application. Sheet metal items shall be furnished in 8- to 10-foot lengths except elastomeric flashing may be furnished in rolls of manufacturer's stock lengths. Single pieces less than 8 feet long may be used to connect to factory fabricated inside and outside corners, and at ends of runs. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades shall be performed by sheet metal mechanics. Accessories and other items essential to complete the sheet metal installation, though not specifically indicated or specified shall be provided. Where sheet metal abuts or extends into adjacent materials, the juncture shall be executed in a manner to assure weather-tight construction. Roof flanges of sheet metal shall be set in plastic bituminous cement over built-up roofing or shall be woven into shingle roofing before nailing. Application of bituminous strip flashing over roof flanges for various sheet metal items is covered in SECTION: BUILT-UP ROOFING. Installation of sheet metal items used in conjunction with roofing, such as gravel stops, shall be coordinated with roofing work to permit continuous roof surfacing operations. Factory fabricated components such as reglets, flashings, gutters, downspouts, and gravel stops shall be packed in cartons which are marked with the manufacturer's name or trademark. Bulk materials from which items are field fabricated shall have manufacturer's name or trademark printed or embossed at frequent intervals to permit easy identification.

.04 MATERIALS shall conform to the respective specifications and other requirements specified below:

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a. Aluminum alloy: (1) Sheets: ASTM Standard B 209, either 3003, 3004, Alclad 3003, Alclad 3004, or Alclad 3005; appropriate temper, unless temper is specified herein. Aluminum items, specified in paragraph EXPOSED SHEET METAL, shall be painted; color to be selected from manufacturers standard colors.

(2) Extrusions: ASTM Standard B 221, alloy 6063, temper T5.

(3) Rivets: ASTM Standard B 316, alloy 1100, 5052, 5056, 6053, or 6061; appropriate temper unless specified.

(4) Rivets, screws, bolts, nuts, and wire: ASTM Standard B 211, alloy 1100, 5052, or 6061; appropriate temper, unless otherwise specified.

b. Sealing compound: Sealing compounds referred to herein are specified in SECTION: CALKING AND SEALING.

c. Fastening materials not specified for a particular sheet metal application shall be of the type best suited for the intended purpose. Nails shall be barbed, annular thread or screw type. Aluminum nails, rivets, screws, bolts and nuts shall be used for fastening aluminum items. Stainless steel fastenings shall be used for connecting dissimilar metals.

d. Felt: ASTM Specification D 226, 15-pound type.

e. Bituminous plastic cement: Federal Specification SS-C-153, Type I with asphalt roofing felts and Type II with coal tar roofing felts.

f. Plastic hardsetting sealant: Type as recommended by the aluminum producer.

g. Solder shall conform to Federal Specification QQ-S-571, composition Sn50 for copper and composition Sn60 for stainless steel and lead-coated copper.

h. Soldering flux shall conform to Federal Specification O-F-506, Type I, form A or B.

i. Zinc-chromate primer: Federal Specification TT-P-645.

.05 EXPOSED SHEET METAL: The following items shall be considered as exposed sheet metal: gutters including hangers, downspouts and leaders, downspout heads, gravel stops and fasciae, cap, and eave flashings.

.06 PROTECTION OF ALUMINUM: Aluminum that will be in contact with wet or pressure treated wood, mortar, concrete, masonry, or ferrous metals shall be protected against galvanic or corrosive action by one of the following methods:

a. Contact surface: Aluminum surfaces to be protected shall be solvent cleaned and given a coat of zinc-chromate primer and one coat of aluminum paint.

b. Nonabsorptive tape or gasket shall be placed between the adjoining surfaces and shall be cemented to the aluminum surface using a cement compatible with aluminum.

.07 TYPES OF JOINTS: Joints consist of locked, lapped, butt, riveted, and soldered types. Aluminum thicker than 0.040 inch shall be welded. Aluminum 0.040 inch or less in thickness shall be either lapped for expansion joints or lock joined, riveted, and filled with hard setting sealant. Table II herein indicates the types of joints to be used and the sealants required. Unless otherwise specified, sealants are covered in SECTION: CALKING AND SEALING.

.08 FASTENINGS: a. Nailing of sheet metal shall be confined generally to sheet metal having a width of less than 18 inches. Nailing of flashings shall be confined to one edge only. Nails shall be evenly spaced not over 3 inches on centers and approximately 1/2 inch from edge unless otherwise specified or indicated. Where sheet metal is applied to other than wood surfaces, detailed shop drawings shall include locations for sleepers and nailing strips required to properly secure the work.

b. Cleats shall be provided where specified or required and shall be evenly spaced not over 12 inches on centers unless otherwise specified or indicated. Unless otherwise specified, cleats shall be not less than 2 inches wide by 3 inches long and shall be of the same material and thickness as the sheet metal being installed. One end of the cleat shall be secured with two nails and the cleat folded back over the nailheads. The other end shall be locked into the seam.

c. Bolts, rivets and screws shall be installed where indicated or required.

.09 WELDING, RIVETING, SEAMING AND SEALING: Welding is specified for aluminum of thickness greater than 0.040 inch. Where riveting and sealing are specified for aluminum it shall apply to aluminum 0.040 inch or less in thickness.

a. Welding of aluminum: Joints in aluminum sheets more than 0.040 inch thick shall be welded. Welding shall be of the inert-gas, shielded-arc type.

b. Seams shall conform to the following requirements:

(1) Flat-lock seams shall finish not less than 1 inch wide.

(2) Unsoldered plain-lap seams shall lap not less than 3 inches unless otherwise specified.

(3) Flat seams shall be made in the direction of the flow.

.10 SAMPLES AND CERTIFICATES: a. Samples of materials proposed for use shall be submitted to the Contracting Officer for approval on request. Sufficient samples shall be provided for check testing by the Government as required.

b. Certificates of Compliance with specification requirements shall be submitted in accordance with SPECIAL PROVISIONS.

.11 HANDLING AND STORAGE: Sheet-metal items shall be carefully handled to prevent damage to the surfaces, edges and ends and shall be stored at the site above the ground in a covered, dry location. Damaged items that cannot be restored to like-new condition will be rejected and shall be replaced at no additional cost to the Government.

.12 EXPANSION JOINTS: Expansion and contraction joints for sheet metal shall be provided at 32-foot intervals for aluminum, except that where the distance between the last expansion joint and the end of the continuous run is more than half the required interval spacing an additional joint shall be provided. Joints shall be evenly spaced. Extruded aluminum gravel stops and fasciae shall be joined by expansion and contraction joints at not more than 12-foot spacing.

.13 FLASHINGS shall be installed at intersections of roof with vertical surfaces and at projections through roof. Except as otherwise indicated, cap flashings shall be provided over base flashings. Perforations in flashings made by masonry anchors shall be covered up by an application of bituminous plastic cement at the perforation. Flashing shall be installed on top of joint reinforcement.

.14 EDGE STRIP: A continuous edge strip shall be provided where indicated or specified to secure loose edges of the sheet metal work. Butt joints shall be spaced approximately 1/8-inch apart. The strip shall be fastened to the supporting construction with nails evenly spaced not over 12 inches on centers. Where the fastening is to be made to concrete or masonry, screws shall be used and shall be driven in expansion shields set in concrete or masonry. The strip for fascia anchorage shall be installed to extend below the supporting construction to form a drip and to allow the flashing to be hooked over the lower edge at least 3/4 inch. The strip shall be of sufficient width to provide adequate bearing

area to insure a rigid installation. Where horizontal nailer is vented for insulation and the strip is placed over masonry or concrete the strip shall be installed over 1/16-inch thick metal washers placed at screws. Washers shall be of metal that is electrolytically compatible with the edge strip.

.15 GRAVEL STOPS AND FASCIA shall be provided for roof edges. Sheets shall be fabricated without longitudinal joints except where two-piece fasciae are used when fascia depth exceeds 7 inches. Provision for expansion shall be provided at joints. Factory fabricated internal and external corner units with mitered joints shall be provided. Roof flange and splice plate of the gravel stop and fascia shall extend out on the roof not less than 4 inches, and shall be set in plastic bituminous cement over the roofing felt. Roof flange shall be nailed with nails spaced not greater than 3 inches on centers located within 1 inch of the outer edge of the flange. The fascia section shall not be face nailed except as specified for two-piece fascia. The upper piece of two-piece fascia is the same as specified above except that the fascia depth shall be at least 3-1/2 inches, and it shall overlap the lower fascia not less than 2 inches. The lower piece shall be hooked 1/2 inch over edge strip and splice plate and face nailed on 12-inch centers 1 inch below top of sheet. The upper fascia shall be hemmed 1/2 inch at lower edge and shall be formed to fit tight against lower fascia. Either smooth or corrugated sheets specified hereinafter, may be used at the option of the Contractor. When aluminum is indicated in table I, the gravel stop and fascia may be of extruded aluminum.

a. Gravel Stops shall be formed of sheets or extrusions of standard stock lengths not exceeding ten feet long in conformance to the detail shown on the drawings. Allowance for expansion shall be provided by placing ends of gravel stops one-half inch (1/2") apart at each joint. Each joint shall be covered with a four-inch wide cover of the same material embedded in plastic caulking compound. Joint covers shall hook under the bottom edge of the gravel stop and extend five inches onto the roof and be anchored with wood screws. The horizontal leg of the gravel stop shall be set in a full and continuous bed of plastic cement composed of the type bitumen used in the built-up roof. The center of each ten foot length of extruded type gravel stop shall be anchored into the wood nailer with two No. 10 to No. 12 round head wood screws, one and one-half inches (1 1/2") long. The screws shall be positioned one inch (1") and three and one-half (3 1/2") back of the vertical leg. Both ends of each ten foot length shall be anchored with two screws of the same type and spacing described above; however, the screws shall be placed in slotted holes one-half inch (1/2") long and slightly wider than the diameter of the screws, with the long axis parallel to the gravel stop. Screws for anchoring ends of gravel stops shall be set at the center of the slots and shall not be tightened against the metal in order to provide for expansion and contraction. A ten inch by ten inch

(10" x 10") metal flashing shall be provided at expansion joints. The entire gravel stop shall be flashed to provide a watertight joint with two layers of 15 lb felt set in hot bitumen. The first layer shall be 9" wide and the second layer 12" wide as called for elsewhere under the heading of Felts and Waterproofing. Metal gravel stops shall be not less than .050 aluminum.

(1) Extrusions: The extruded type of aluminum gravel stop and fascia shall be a factory fabricated, prepackaged, complete system with fastenings, of the style indicated. The system shall be installed in accordance with the manufacturer's recommendations and the other requirement herein specified. Extruded cover plate shall be provided over each joint. Aluminum sheet flashing 0.025 inch thick by at least 12 inches wide and having a depth to within 1 inch of the bottom edge of fascia shall be applied under the gravel stop and fascia at each joint.

(2) Sheets, smooth: Joining shall be as specified in Table II. Joints shall have a concealed clip soldered or welded near one end of each sheet to hold the adjoining sheet in lapped position. The clip shall be approximately 4 inches wide and shall be the full depth of the fascia less 1 inch at top and bottom. Clip shall be of the same thickness as the fascia. The lower edge of fascia shall be hooked 3/4 inch over an edge strip specified in paragraph EDGE STRIP. The lower hooked edge shall be bent outward at an angle of 30 degrees. When fascia exceeds 6 inches in depth, one or more horizontal steps not less than 1/2 inch high shall be formed in the fascia. When fascia exceeds 7-inch depth, two-piece fascia shall be used.

.16 PAINTING: Sheet metal work shall not be field painted except as required for protection of aluminum.

TABLE 1 - SHEET METAL WEIGHTS, THICKNESSES, AND GAGES

<u>Item Description</u>	<u>Aluminum, Inch</u>
Building expansion joints:	
Cap.....	.032
Covering on minor flat, pitched or curved surfaces.....	.040
Downspouts and leaders.....	.032
Downspout clip and anchor.....	.040 clip .125 anchor
Downspout straps, 2-Inch.....	.060
Downspout heads	.032
Scupper lining.....	.032
Strainers, wire diameter or gage...	.144 dia.
Flashings:	
Base.....	.040
Cap.....	.032
Stepped.....	.032
Valley.....	.032
Gravel stops and fascia:	
Extrusions.....	.075
Sheets, smooth.....	.050
Edge strip, 1-1/3-inch thick.....	.050
Gutters:	
Gutter section.....	.032
Continuous cleat.....	.032
Hangers, dimensions.....	1" x .080"
Cover plates.....	.032
Pitch pockets.....	.032
Reglets.....	(a)
Splash pans.....	.040

(a) Use polyvinyl chloride.

TABLE II - SHEET METAL JOINTS

Item Designation	Type of Joint Aluminum	Remarks
Joint cap for building expansion joint at roof.	1 1/4-inch single lock, standing seam, cleated.	
Flashings:		
base	1-inch flat locked, sealed 3-inch lap for expansion joint, sealed.	Aluminum producer's recommended hard setting sealant for locked aluminum joints. Each expansion joint for all metals shall have one continuous strip of 1/16-inch thick by 1/4-inch wide No. 7 sealant.
cap-in reglet	3-inch lap	Seal groove with No. 1 sealant (a).
reglets		Seal reglet groove with No. 1 Sealant (a).
stepped	3-inch lap.	
valley	6-inch lap, cleated.	
Edge strip	Butt.	
Gravel stops:		
Extrusions	Butt with 1/2-inch space.	Use sheet flashing beneath and a cover plate.
Sheet, smooth	Butt with 1/2-inch space.	Use sheet flashing beneath and a cover plate.
Sheet, corrugated	Butt with space	Use sheet flashing beneath and a cover plate or combination unit.

(a) Polyvinyl chloride type reglet shall be sealed with manufacturer's recommended butyl rubber sealant.

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TABLE II - SHEET METAL JOINTS (continued)

Item Designation	Type of Joint Aluminum	Remarks
Gravel stops (contd):		
Gutters	1-inch flat locked, riveted and sealed.	Aluminum producers recommended hard setting sealant for locked aluminum joints.
Pitch pockets	1-inch flat locked and sealed.	Aluminum producers recommended hard setting sealant for locked aluminum joints.

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TECHNICAL PROVISIONS
SECTION 16D
ELECTRICAL WORK, INTERIOR

.01 SCOPE: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, supplies and materials, and in performing all operations necessary for the installation of an interior electrical wiring system, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

.02 APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

a. Federal Specifications:

J-C-30A & Am-1	Cable and Wire, Electrical (Power, fixed installation).
W-F-408C & Am-1	Fittings for Conduit, Metal, Rigid, (Thick-Wall and Thin-Wall (EMT) Type).
W-J-800D	Junction Box; Extension, Junction Box; Cover, Junction Box (Steel, Cadmium, or Zinc-Coated).
W-P-455a & Am-6	Plate, Wall Electrical.
W-S-610C & Am-1	Splice Conductor.
HH-I-510D	Insulation Tape, Electrical, Friction.
HH-I-553C & Am-1	Insulation Tape Electrical (Rubber, Natural and Synthetic).
HH-I-595C	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic.
WW-C-563A	Conduit, Metal, Rigid: Electrical, Thin-Wall Steel Type (Electrical Metallic Tubing); Straight Lengths, Elbows, and Bends.

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b. National Fire Protection Association (NFPA) Publication:

No. 70-1978 National Electrical Code.

c. Underwriters Laboratories, Inc. (UL) Standards:

Building Materials Directory (January 1978 with Quarterly Supplements).

UL 20 General-Use Snap Switches
(Oct 15, 1974; Rev. thru Dec 6, 1976).

UL 50 Cabinets and Boxes (June 20, 1975; Rev
thru Sep 11, 1978).

.03 GENERAL: a. Rules: The installation shall conform to the requirements of the National Electrical Code, and the requirements specified herein. In case of any differences or discrepancies between the specifications and the National Electrical Code, the specifications shall govern.

b. Coordination: The contract drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The contractor shall study building plans and details so that the outlets and equipment will be properly located and readily accessible. Equipment and outlets shall be located to avoid interference with mechanical or structural features. If any conflicts occur necessitating departures from the contract drawings, details of departures and reasons therefor shall be submitted as soon as practicable for written approval of the Contracting Officer.

c. Capacities of equipment and material shall be not less than those indicated.

.04 MATERIALS AND EQUIPMENT shall conform to the respective publications and other requirements specified below. Other materials and equipment shall be as specified elsewhere herein as shown on the drawings and shall be the products of the manufacturers regularly engaged in the manufacture of such products.

a. Conductors, Insulated: Federal Specification J-C-30, types as specified.

- b. Connectors, wire pressures: Federal Specification W-S-610.
- c. Device plates: Federal Specification W-P-455.
- d. Fittings, cable and conduit: Federal Specifications W-F-406 and W-F-408.
- e. Outlet boxes: Sheet-steel outlet boxes: Federal Specification W-J-800.
- f. Receptacles: Federal Specification W-C-596.
- g. Splice, conductor: Federal Specification W-S-610.
- h. Switches: Snap switches: UL Standard 20.
- i. Tape:
 - (1) Friction tape: Federal Specification HH-I-510.
 - (2) Plastic tape: Federal Specification H-I-595.
 - (3) Rubber tape: Federal Specification HH-I-553.
- j. Tubing, electrical, zinc-coated metallic steel: Federal Specification WW-C-563.

.05 APPROVAL OF MATERIALS AND EQUIPMENT will be based on the manufacturer's published data.

a. The label or listing of the Underwriters Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this listing the contractor shall submit a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements.

b. A manufacturer's statement indicating complete compliance with the applicable Federal Specification, Military Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers, or other commercial standard, is acceptable.

.06 WORKMANSHIP: All materials and equipment shall be installed in accordance with recommendations of the manufacturer as approved by the Contracting Officer, to conform with the contract documents. The installation shall be accomplished by workmen skilled in this type of work.

.07 GROUNDING: Except where specifically indicated otherwise, all exposed non-current-carrying metallic parts of electrical equipment, metallic raceway system and neutral conductor of the wiring system shall be grounded. The ground connection shall be made at the main service equipment.

.08 WIRING METHODS: a. General: Unless otherwise indicated, wire shall consist of insulated conductors installed in rigid electrical metallic tubing.

b. Conduit (and tubing) systems shall be installed as indicated. Minimum size of raceways shall be 1/2 inch. Electrical metallic tubing may be installed in concrete and grout in dry locations. Electrical metallic tubing may be installed only within buildings. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 6 inches away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed where possible within finished walls, ceilings, and floors other than slab-on-grade.

(1) Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings.

(2) Change in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be taken to prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment during the course of construction. Clogged raceways shall be entirely freed of obstructions or shall be replaced.

(3) Supports: Raceways shall be securely supported and fastened in place at intervals of not more than 10 feet with pipe straps, wall brackets, hangers, threaded C-clamps with retainers, or ceiling trapeze. Fastenings shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine or wood screws. Raceways or pipe straps shall not be welded to steel structures. In suspended-ceiling construction, only lighting-system-branch-circuit raceways shall be fastened to the ceiling supports. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts where required by the National Electrical Code, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Bushing shall be installed on the ends of all conduits and shall be of the insulating type where required by the National Electrical Code. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered; those installed in wet locations shall be raintight.

c. Conductors in raceways and cable shall be of copper, unless otherwise indicated. Solderless pressure connectors, properly taped and wire connectors of insulating material shall be used for all splices where practicable. Wire connectors of insulating material or solderless pressure connectors properly taped shall be utilized for all splices where possible.

(1) Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 American Wire Gage.

(2) Insulation: Insulated conductors shall conform to the requirements of the National Electrical Code for application.

.09 BOXES AND SUPPORTS: Boxes shall be provided in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes shall be sheet steel. Each box shall have the volume required by the National Electrical Code for the number of conductors enclosed in the box. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. Boxes for use with raceway systems shall not be less than 1-1/2 inches deep except where shallower boxes required by structural conditions are approved. Boxes for other than lighting-fixture and telephone outlets shall be not less than 4 inches square except that 4- by 2-inch boxes may be used where only one raceway enters the outlet.

.10 DEVICE PLATES of the one-piece type shall be provided for all outlets and fittings to suit the devices installed. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, cast metal, or impact resistant plastic having rounded or beveled edges. Plates on finished walls shall be of steel or impact resistant plastic with brown baked-enamel finish. Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional-type device plates will not be permitted.

.11 RECEPTACLES: Duplex receptacles shall be rated 15 amperes, 125 volts, two-pole, three-wire, grounded type with polarized parallel slots, in accordance with Federal Specification W-C-596. Bodies shall be of brown phenolic compound supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or backed-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke.

.12 WALL SWITCHES shall be of the totally enclosed tumbler type with bodies of phenolic compound. Handles shall be brown. Wiring terminals shall be of the one screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than one switch shall be installed in a single-gang position. Switches shall be rated 20-ampere for use on alternating current only.

.13 REPAIR OF EXISTING WORK: The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for the proper

installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Government.

.14 TESTS: After the interior-wiring-system installation is completed, and at a time coordinated in advance with the Construction inspector, the contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Contracting Officer or an authorized representative. The contractor shall furnish all instruments and personnel required for the tests, and the Government will furnish the necessary electric power.

FORT KNOX, KENTUCKY

PR. 69-79

P.E. 108-79

SPECIFICATIONS
FOR
REPLACEMENT OF ROOF ON BUILDING 6576
AT
FORT KNOX, KENTUCKY
21 AUGUST 1979

PART NO.

I

TITLE

Technical Provisions

PAGE NO.

IA-01 - 7F-03

ADDENDUM NO. 1

TO

SPECIFICATIONS P.E. 108-79

FOR

REPLACEMENT OF ROOF ON BUILDING 6576

AT

FORT KNOX, KENTUCKY

30 August 1979

Specifications P.E. 108-79, dated 21 August 1979, shall be amended in these particulars and these particulars only:

1. Division 1, Section 1B Working Conditions, Page 1b-01, delete paragraph 1.6 in its entirety and change paragraph reference number 1.7 to read 1.6 and 1.8 to read 1.7.
2. Division 7, Section 7E Sheet Metal Work, General:
 - a. Page 7E-1, Paragraph 1.1; add the following: QQ-L-201F & Am 2 dated 17 Nov 70 Lead Sheet.
 - b. Page 7E-2 add the following:
4.7 Lead Sheet: Federal Specification QQ-L-201, Grade B, minimum weight 4 pounds per square foot.
 - c. Page 7E-5 add the following:
14.5 Vent Pipe Flashing: Flash with a 4 pound lead sleeve having a 6 inch flange. Set flange in plastic bituminous cement over roofing felts. Flange shall be nailed with nails spaced not more than 3 inches on center located within 1 inch of the outer edge of the flange. Top of sleeve shall be bent over and extended down into the vent pipe a minimum of 2 inches.

END

ADDENDUM NO. 2
TO
SPECIFICATION P.E. 108-79
FOR
REPLACEMENT OF ROOF ON BUILDING 6576
AT
FORT KNOX, KENTUCKY
11 SEPTEMBER 1979

Specifications P.E. 108-79, dated 21 August 1979, with Addendum No. 1, dated 30 August 1979, shall be amended in these particulars and these particulars only:

1. Division 1, Section 1A, Description of Work, paragraph 3.8; after the word new add the phrase: gravel stops.
2. Division 1, Section 1C, Environment Protection, paragraph 4.3, delete the phrase: concrete slab.
3. Division 2, Section 2A, Demolition:
 - a. Page 2A-01, paragraph 2.2, Line 2, after the phrase "dust to" add the following phrase: stationary equipment adjacent to and.
 - b. Page 2A-02, Paragraph 4.1, the word completed should be changed to read: Complete.
 - c. Page 2A-02, Paragraph 5.1, delete the word completed and add the phrase: shall be removed complete.
 - d. Page 2A-02, Paragraph 6.2, delete the phrase: reinstalled prior to commencing roofing work; and add the phrase: reinstall same.
4. Division 6, Section 6A, Rough Carpentry/Fasteners and Supports.
 - a. Page 6A-01, Paragraph 1.1, add the following:

TT-P-38 & Am 1	Paint, Aluminum, Ready-mixed.
Dated 04 Nov 74	
TT-P-641 & Am 1	Primer Coating, Zinc, Dust-zinc Oxide
Dated 23 Jan 77	(For Galvanized Surfaces)
 - b. Page 6A-02, Paragraph 2.1.5, change the word nails to read: Fasteners, and change the word steel to read: Fasteners; and add the

phrase: Shall be steel and.

- c. Page 6A-02: Add the following paragraph:

2.3.6 All welds shall receive one coat of primer conforming to Fed. Spec. TT-P-641, 1.5 Mil thick, brush applied and one coat of paint conforming to Fed. Spec. TT-P-38, 1.5 Mil thick, brush applied.

- d. Page 6A-03, Paragraph 10.1, change the word nails to read: Fasteners.

- e. Page 6A-03, Paragraph 10.1, between the words with and recommended delete the word: Fasteners.

5. Division 7, Section 7A, Insulation For Roofing.

- a. Page 7A-1, Paragraph 1.2, revise to read as follows:

D 312-78	Asphalt used in Roofing
D 2626-73	Asphalt-Saturated and Coated Organic Felt Used in Roofing

and add the following:

D 2822-75	Asphalt Roof Cement
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- b. Page 7A-2, Paragraph 2.3.3, following the word tankers in Line 11 add the following: Kettlemen shall be in attendance at all times during the heating to insure that the maximum temperature is not exceeded.

- c. Page 7A-3, Paragraph 3.4, following the word insulation delete the phrase: 2-2 Feet square sample and add the following phrase: One full size section; and add the following phrase: Bituminous Cement-1 Gallon.

- d. Page 7A-3, Paragraph 4.2.1, following the word type, delete the phrase: 1 or.

- e. Page 7A-3, Paragraph 4.3.3, delete the second sentence in its entirety; and following the word securing delete the word other.

- f. Page 7A-3, add the following paragraph:

4.5 Bituminous Cement: ASTM D 2822, Type I.

- g. Page 7A-4, Paragraph 7.1.1, Line 6, following the word lifted add the phrase: or rocked in place.

- h. Page 7A-4, Paragraph 7.1.2, Line 4, following the word Asphalt add the phrase: Per square; and delete the fourth sentence in its entirety.

- i. Page 7A-5, add the following paragraph: 8.3 Nailers shall be

anchored to resist a force of 75 pounds per linear foot in any direction.

6. Division 7, Section 7B, Built-up Roofing.

a. Page 7B-01, Paragraph 1.1:

(1) Revise the first item to read as follows:

D 226-77 Asphalt-Saturated Organic Felt Used in
Roofing and Water Proofing.

(2) Revise the second item to read as follows:

D 312-78 Asphalt Used in Roofing

(3) Revise the third item to read as follows:

D 1863-77 Mineral Aggregate Used on Built-up Roofs.

b. Page 7B-02, Paragraph 4.1, change the phrase: Type I to read: Type III.

c. Page 7B-03, Paragraph 4.5, following the word bags add the phrase: and store in a dry place.

d. Page 7B-03, Paragraph 6.2.3, Line 8, change the word following the to read manufacturer's, and following the word square in line 11, add the following: Kettlemen shall be in attendance at all times during the heating to insure that the maximum temperature is not exceeded.

e. Page 7B-04, Paragraph 6.2.4, in line 10, following the word to add the phrase: 2 inches above.

f. Page 7B-07, Table I, add the following: End laps of roofing felts shall be not less than 6 inches and shall be staggered a minimum of 12 inches.

7. Division 7, Section 7C, Elastomeric Roofing (EPDM)

a. Page 7C-2, Paragraph 3.4, Line 10, change the word following bonding to read: Adhesive.

b. Page 7C-2, Paragraph 3.5, following the word sheets change the period to a comma and add the following: Outline of roof and roof size, perimeter details, special details and bill of materials.

c. Page 7C-3, Paragraph 5.3, Line 1, following the word be, add the following: Positioned without stretching over the insulation. Allow 1/2 hour to relax membrane, reposition in place to remove wrinkles. Membrane shall then be.

- d. Page 7C-3, Paragraph 5.2, Line 3, delete the phrase: Built-up.
 - e. Page 7C-4, add the following paragraph: Warranty: Manufacturer's Standard Warranty.
8. Division 7, Section 7D, Elastomeric Roofing, Fluid Applied.
- a. Page 7D-01, Paragraph 1.1:
 - (1) Revise the second item to read as follows:
D 312-78 Asphalt used in Roofing
 - (2) Revise the fourth item to read as follows:
D 1622-78 Apparent Density of Rigid Cellular Plastics
 - (3) Revise the fifth item to read as follows:
D 2626-73 Asphalt-saturated and Coated Organic Felt
Used in Roofing
 - b. Page 7D-02, Paragraph 2.4.4, delete the phrase: After cleaning.
 - c. Page 7D-03, Paragraph 3.4, following the word coating change 2 to read: 6; following the word course change 1 to read: 2.
 - d. Page 7D-03, Paragraph 5.1, delete in its entirety and add the following:
 - 5.1 Base Sheet
 - 5.1.1 Apply one layer of roofing felts with 4 inch side laps and 6 inch end laps staggered at least 12 inches, without mopping, at right angles to the direction of the slope.
 - 5.1.2 Fasten to deck with roofing fasteners for gypsum. Nail 9 inches on center at side laps, and two rows 11 inches apart down the center of the sheet with nails 18 inches on center staggered.
 - 5.1.3 End and side laps shall be solidly embedded in a layer of asphalt roof cement to form a waterproof joint between plys.
 - 5.1.4 Asphalt roof cement shall not extend greater than 1 1/2 inches beyond edge of lapping ply on end and side laps.
 - e. Page 7D-04, Paragraph 5.2, Line 2, following thickness, delete the phrase. Of one inch; and add the following phrase: As indicated on the drawings.
 - f. Page 7D-04, Paragraph 5.3.1, line 2, following the word for, delete the number 12.

g. Page 7D-05, Paragraph 5.6, Line 2, following the word fabric delete the phrase: 24 to 48 inches wide; and add the following: 24 inches wide by 48 inches long.

h. Page 7D-05, Paragraph 7.3, Line 1, following the word course, change one to read: two.

i. Page 7D-05, add the following paragraph: 7.4 Walk Surface: A sample 2 foot x 4 foot shall be taken of complete roof system including the walk surface.

j. Page 7D-05, add the following paragraph: Warranty: Manufacturer's Standard Warranty.

9. Division 7, Section 7E, Sheetmetal Work, General

a. Page 7E-1, Paragraph 1.1, Delete the third item in its entirety.

b. Page 7E-1, Paragraph 1.2, add the following:

D 2822-75 Asphalt Roof Cement

c. Page 7E-1, Paragraph 2, Line 16, delete the word: Bituminous.

d. Page 7E-2, Paragraph 4.4, delete the phrase: Federal Specification SS-C-153; and add the following: ASTM D 2822.

e. Page 7E-4, Paragraph 11.3, Line 4, change the word following outer, to read: Flat; and line 13, change the phrase following masonry, to read: with lags.

f. Page 7E-5, Paragraph 12, Line 10, delete the phrase: Set in plastic bituminous cement and; and line 11, delete the phrase: with strips on roofing felt; and line 11, prior to specified, add the word: As.

g. Page 7E-5, Paragraph 13, Line 2, change the number 40 to read: 32.

h. Page 7E-5, Paragraph 14.2, following cleaned, add the following: Pretinned.

i. Page 7E-5, Paragraph 15, line 1, prior to A, add the phrase: Continuous Cleat.

j. Page 7E-6, Paragraph 16, Line 6, change the word following less, to read: than; and line 7, following felt, add the phrase: of the built-up roof; and delete the last two sentences in their entirety.

10. Drawing No. MB10156, Sheet 1 thru 3 of 3, Revision No. 1, dated Sep 79, with Revisions as indicated.

END

PR. 69-79

P.E. 108-79

SPECIFICATIONS
FOR
REPLACEMENT OF ROOF ON BUILDING 6576
AT
FORT KNOX, KENTUCKY
21 AUGUST 1979

PART NO.

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PAGE NO.

I

Technical Provisions

1A-01 - 7F-03

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TECHNICAL PROVISIONS
DIVISION 1
SECTION 1A
DESCRIPTION OF WORK

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1. Work to be done.
2. Location.
3. Principal Features.
4. Drawings.
5. Payment.

PART I

TECHNICAL PROVISIONS

DIVISION 1

SECTION 1A

DESCRIPTION OF WORK

1. WORK TO BE DONE: The work consists of furnishing all plant, labor and materials (except as indicated otherwise in the contract documents) required for replacement of roof on building 6576.

2. LOCATION: The site of the work contemplated by these specifications is located at Fort Knox, Kentucky, approximately thirty (30) miles south of Louisville, Kentucky, and approximately seventeen (17) miles north of Elizabethtown, Kentucky, on US Highway 31W and the Illinois Central Railroad.

3. PRINCIPAL FEATURES: The work to be performed includes the following principal features:

3.1 Remove existing coal tar built-up roofing.

3.2 Remove existing gutters, downspouts and accessories.

3.3 Preparation of roof deck to receive new roofing including installation of vapor retarder membrane and existing wood nailer repair by replacement as required.

3.4 Installation of insulation for elastomeric roofing (EPDM) and built-up roofing.

3.5 Installation of elastomeric roofing (EPDM).

3.6 Installation of elastomeric roofing, fluid applied.

3.7 Installation of built-up roofing.

3.8 Installation of new gutters, downspouts and accessories.

4. Drawings: Work shall be accomplished in accordance with these specifications and the following drawings:

DRAWING NO.

TITLE

MB 10156
Sheets 1 thru 3

Reroof Building 6576; roof test.

5. PAYMENT: Will be made on the basis of bid items listed and on the actual quantities of materials installed for unit price bid items.

1B-01

PART I
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DIVISION 1

SECTION 1B

WORKING CONDITIONS

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1. General.
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3. Schedule of Work.
4. Coordination.
5. Reporting for Work.
6. Protection.

PART I
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DIVISION 1
SECTION 1B
WORKING CONDITIONS

1. GENERAL:

1.1 Work site is Building No. 6576, located in Farmer Motor Park as shown on site location map.

1.2 The building will be occupied during the work contemplated by these specifications. Every precaution shall be taken to prevent conditions that may be hazardous to life and property.

1.3 Work operations shall be accomplished in such a manner as to minimize any inconvenience to the occupants and interruptions to the normal operations of the facility.

1.4 The nature of this project is to provide a full scale test of new re-roofing systems. Roofs will be monitored both during construction and after completion.

1.5 The Government reserves the right to award any or all bid items to one or several bidders as it deems necessary to assure qualified contractors to accomplish the work and best serve the requirements of the Government.

1.6 A pre-bid conference is scheduled for approximately ten (10) days prior to receipt of bids. Contractors are encouraged to attend.

1.7 The contractor shall be responsible to visit the work site and become familiar with all aspects of the work to be accomplished, including site conditions, drawings, specifications, bidding requirements and the bid schedule.

1.8 Contractor shall provide a trailer or other storage facility to provide adequate storage of materials as specified by these specifications. Trailer or other storage facility shall be located in the area designated by the Contracting Officer.

2. TEST PROCEDURES:

2.1 Construction of roofs will be visually inspected and recorded photographically by the Government during the construction period.

2.2 Thermocouples and strain gauges will be installed by the Government to monitor temperature and strain in each roof system.

1B-02

2.2.1 Two (2) thermocouples will be installed on the existing gypsum deck surface after existing built-up roof is removed and before new construction is started.

2.2.2 The contractor shall notify the Government twenty-four (24) hours in advance when roof deck is clean and provide the Government time to install thermocouples on the gypsum deck.

2.2.3 The balance of the monitoring devices will be installed after construction is complete.

2.3 Material samples and roof tests required by these specifications will be used by the Government to determine compliance of materials and workmanship to these specifications and to be tested to obtain required data for evaluating performance of roofing systems.

2.4 The experimental nature of this project requires experienced, competent contractors be employed to accomplish work required. To this end contractors shall be required to have the following qualifications:

2.4.1 Contractor shall have a minimum of three (3) years experience in roof system(s) for which he is bidding.

2.4.2 Contractors bidding on Elastomeric Roofing Systems (EPDM and fluid applied) shall be an applicator for system approved as qualified by the system manufacturer. Applicator shall be normally engaged in the installation of such system.

2.4.3 Contractors bidding on Elastomeric Roofing Systems (EPDM and fluid applied) shall submit a list of previous projects employing roof system, for which bid is being submitted, of 20 squares or more. List shall include name of project, owner, address of project, and year and month completed.

2.4.4 Contractors bidding on built-up roofing system shall submit a list of previous projects employing built-up roof systems of 50 squares or more completed within three (3) years of bid date. List shall include name of project, owner, address of project, and year and month completed.

2.4.5 Contractors shall submit with bid proposal a notarized statement of compliance with above qualification requirements and list of previous projects as required. Proof of contractor qualification shall be submitted as requested by the Contracting Officer.

3. SCHEDULE OF WORK:

3.1 Contractor shall submit to the Contracting Officer, within five (5) days of receipt of Notice to Proceed, for his approval a schedule of work components. Work shall not commence before schedule is approved. Schedule shall include starting and completion dates of each work component.

3.2 A work component shall consist of a work item as described under the principal features of the Description of Work, Section 1A..

3.3 Work shall not commence on a work component before construction materials are available, and required submittals, samples and tests are taken or approved.

3.4 Changes or deviations to the work schedule shall be coordinated with and approved by the Contracting Officer.

4. COORDINATION:

4.1 Work to be performed under this contract shall be coordinated with the Contracting Officer, or his Authorized Representative.

4.2 The contractor shall coordinate and obtain permission from the Contracting Officer or his Authorized Representative, before any interruption of existing utilities or power shut off.

4.3 Contractor shall submit the name of superintendent(s) for each work component.

4.4 Contractor shall be required to coordinate his work operations with those of other contractors in the event of multiple contract awards. Coordination shall be through the Contracting Officer or his Authorized Representative.

5. REPORTING FOR WORK:

5.1 The contractor's superintendent shall report at the beginning of each work day the area of work and any work that could be hazardous.

5.2 Areas which remain hazardous overnight or for a period of time, in excess of twenty-four (24) hours, shall be reported to the Contracting Officer or his Authorized Representative by the Contractor's superintendent.

5.2.1 Report area of hazardous work, nature of hazard and duration of hazard.

5.2.2 Hazards of an emergency nature shall be corrected immediately and reported to the Contracting Officer.

5.3 Order of work shall be accomplished as shown on the schedule submitted by the contractor and approved by the Contracting Officer.

6. PROTECTION:

6.1 Work shall be accomplished in such a manner to protect work to remain and adjacent surfaces and objects from damage.

6.2 Work or adjacent objects damaged by the Contractors operation shall be repaired or replaced to original condition at no cost to the Government.

PART I
TECHNICAL PROVISIONS
DIVISION 1
SECTION 1C
ENVIRONMENT PROTECTION

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1. Scope.
2. General.
3. Protection of Land Resources.
4. Disposal of Material and Other Debris.
5. Dust Control.

PART I

TECHNICAL PROVISIONS

DIVISION 1

SECTION 1C

ENVIRONMENT PROTECTION

1. SCOPE: This section covers the furnishings of all labor, materials and equipment and performing all work required for the protection of the environment during construction operations except for those measures set forth in other Technical Provisions of these specifications.
2. GENERAL: For the purpose of this specification, environment protection is defined as the retention of the environment in its natural state to the greatest possible extent during project construction and to enhance the natural appearance in its final condition. Environment protection requires consideration of air and land involves noise as well as other pollutants. In order to prevent, and to provide for abatement and control of, any environmental pollution arising from the construction activities in the performance of this contract, the Contractor and his subcontractors shall comply with all applicable Federal, State, and local laws and regulations concerning environmental pollution control and abatement.
3. PROTECTION OF LAND RESOURCES:
 - 3.1 General: The land resources within the project boundaries and outside the limits of work performed under this contract shall be preserved in their present condition or be restored to a condition after completion of construction that will appear to be natural and not detract from the appearance of the project.
4. DISPOSAL OF MATERIAL AND OTHER DEBRIS:
 - 4.1 Material and debris generated during the work shall be disposed of at the end of each day.
 - 4.2 Non-salvageable materials and debris shall be hauled to the sanitary land fill area located off Brandenburg Road and disposed of as directed by the Contracting Officer or his Authorized Representative.
 - 4.3 Debris, such as rock, dirt, concrete slab, generated by the construction shall be disposed of in an area of the land fill area designated for that purpose.
5. DUST CONTROL: The Contractor will be required to maintain all work areas within the project boundaries free from dust and other airborne pollutants which would cause a hazard or nuisance to others.

PART I
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DIVISION 2

SECTION 2A

DEMOLITION

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5. Removal of Gutters and Downspouts
6. Miscellaneous Removals
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PART I

TECHNICAL PROVISIONS

DIVISION 2

SECTION 2A

DEMOLITION

1. APPLICABLE PUBLICATIONS: The applicable provisions of the following publications listed below form a part of this specification.

1.1 Department of Labor:

Occupational and Health Standards (29 CFR - Part 1910)

Safety and Health Regulations for Construction (29 CFR - Part 1518)

2. GENERAL:

2.1 Procedures: The procedures proposed for the accomplishment of salvage and demolition work shall provide for safe conduct of the work, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services.

2.2 Dust Control: The amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the building and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions such as ice, flooding and pollution.

2.3 Protection of Existing Work:

2.3.1 Existing work to remain shall be protected from damage. Work damaged by the Contractor shall be repaired in accordance with the requirements of Section: WORKING CONDITIONS.

2.3.2 Cover items to remain as necessary to protect from dust.

2.3.3 Existing gypsum deck shall be protected with weather proof cover during inclement weather.

2.4 Environmental Protection: All work and Contractor operations shall comply with the requirements of Section: ENVIRONMENTAL PROTECTION.

3. DISPOSITION OF MATERIALS:

3.1 All materials removed shall remain the property of the Government.

3.2 Disposition of material shall be as specified in Section: ENVIRONMENT PROTECTION.

4. REMOVAL OF EXISTING ROOFING:

4.1 Existing roof deck shall be stripped of roofing membrane, vapor barrier, embedded flashing, nails, fasteners, deteriorated nailers and related accessories completed.

4.2 Surface shall be swept clean and shall be free of rough edges or items that may penetrate the new roof system. Objects having a girth of 1/16 inch or greater shall be removed.

4.3 All debris shall be removed from the roof using a covered chute or other device to minimize the spread of dust and debris. Ground area around chute shall be cleaned immediately after completion of stripping activities.

4.4 Debris and other items removed shall not be allowed to fall free a vertical distance to exceed 3 feet.

4.5 Stripping shall be limited to area to be reroofed during the same day.

5. REMOVAL OF GUTTERS AND DOWNSPOUTS:

5.1 Existing galvanized iron gutters, downspouts, hangers, straps, fasteners, nails and related accessories completed.

5.2 Debris and other items removed shall not be allowed to fall free a vertical distance to exceed 3 feet.

6. MISCELLANEOUS REMOVALS:

6.1 Existing copper cap flashing shall be turned up as indicated on drawing and turned down over base flashing after roofing work is completed.

6.1.1 Repairs to cap flashing shall be accomplished as specified in Section: SHEET METAL WORK, GENERAL.

6.1.2 Remove face nails on cap flashing.

6.1.3 Bending of metal shall be accomplished in a manner to protect metal from damage and inducing stresses in metal.

6.2 Remove existing exhaust fan and motor and reinstalled prior to commencing roofing work.

6.2.1 Disconnect and reconnect electrical service as required.

6.2.2 Handle and store equipment to protect from damage.

6.2.3 Roof curb to set equipment on is specified in Section: ROUGH CARPENTRY/FASTENERS AND SUPPORTS.

6.3 Weather heads and supports shall be loosened as required to install the work and resecured.

6.4 Remove complete or remove and reinstall items indicated or required to complete the work.

7. CLEAN-UP:

7.1 Debris and Rubbish: Remove debris and rubbish from the site daily. Do not allow to accumulate on site.

7.2 Debris Control: Remove and transport debris in a manner as to prevent spillage on streets or adjacent areas.

7.3 Regulations: Local regulations regarding hauling and disposal apply.

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SECTION 6A

ROUGH CARPENTRY/FASTENERS AND SUPPORTS

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9. Installation of Nailers
10. Installation of Prefabricated Equipment Supports

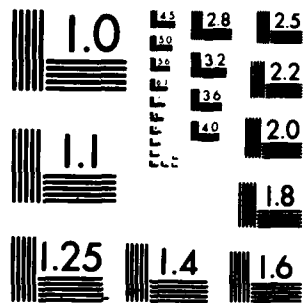
AD-A109 595 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 13/13
CONSTRUCTION OF EXPERIMENTAL ROOFING.(U)
NOV 81 M J ROSENFELD, D E BROTHERRSON

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PART I

TECHNICAL PROVISIONS

DIVISION 6

SECTION 6A

ROUGH CARPENTRY/FASTENERS AND SUPPORTS

1. APPLICABLE PUBLICATION: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references there-to:

1.1 Federal Specification (Fed. Spec.):

FF-N-105B Nails, Brads, Staples and Spikes: Wire,
& Am-4 Cut and Wrought.
Dated 23 Aug 77

QQ-S-775E Steel Sheets, Carbon, Zinc Coated (Gal-
Dated 10 Feb 76 vanized) by the Hot-Dip Process

1.2 U. S. Department of Commerce, Product Standard (Prod. Std.):

PS 20-70 American Softwood Lumber Standard.
& Am-1.

1.3 American Wood Preservers Bureau (AWPB), Standard:

LP-2. Softwood Lumber, Timber and Plywood Pres-
 sure Treated With Water-Borne Preserva-
 tives for Above Ground Use (Rev. Jul 1975).

2. MATERIALS shall conform to the respective specifications and other requirements specified below:

2.1 Accessories and nails:

2.1.1 Anchor Bolts: Steel, size as indicated, complete with nuts and washers.

2.1.2 Bolts: lag, toggle, and miscellaneous bolts, and screws: Type, size, and finish best suited for intended use.

2.1.3 Expansion shields: Type and size best suited for intended use.

2.1.4 Nails and staples: Size and type best suited for purpose, in accordance with Fed. Spec. FF-N-105 when applicable to type used. Length

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of nails shall be sufficient to extend 1 inch into supports. In general, 8-penny or larger nails shall be used for nailing through 1-inch thick lumber and for toe nailing 2-inch thick lumber; 16-penny or larger nails shall be used for nailing through 2-inch thick lumber.

2.1.5 Roofing nails for gypsum deck: Steel shall be designed with two piece stem which spreads when driven into gypsum deck and produces an inverted wedge shape with minimum 40 pounds withdrawal force per fastener.

2.2 Nonstress graded members shall include blocking and nailers. Members shall be standard grade or No.2 grade. Nonstress member grades shall conform to the National Grading Rule for Dimension Lumber established in conformance with Section 10 of Prod. Std. PS 20 and as applied in individual grading rules of applicable grading agencies. For species graded under other grading rules, grade used shall be equivalent to grades outlined above. Sizes shall be as required and shown on drawings.

2.3 Pre-fabricated Equipment Supports:

2.3.1 Fabricate from 18 gauge galvanized steel conforming to Fed. Spec. QQ-S-775.

2.3.2 All seams shall be welded.

2.3.3 Shall be furnished with base plate welded to curb, treated wood nailer, 18 gauge galvanized steel cap flashing and required galvanized fasteners.

2.3.4 Treated wood nailer shall be treated in accordance with AWPB LP-2.

2.3.5 Fasteners exposed shall have neoprene washers.

3. GRADING AND MARKING: Lumber shall bear the grademark, stamp or other identifying marks indicating grades of material and rules or standards under which produced. Such identifying marks on a material shall be in accordance with the rule or standard under which the material is produced, including requirements for qualifications and authority of the inspection organization, usage of authorized identification, and information included in the identification. The inspection agency for lumber shall be certified by the Board of Review, American Lumber Standards Committee, to grade species used. Bundle marking or certificates will not be permitted in lieu of marking each individual piece.

4. SIZES: Lumber sizes shall conform to Prod. Std. PS 20, and unless otherwise specified, lumber shall be surfaced on four sides. Sizes for materials other than lumber shall conform to requirements of the rules or standards under which produced. Size references unless otherwise specified are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the standard under which the product is produced.

5. MOISTURE CONTENT: At the time lumber is delivered and when installed in the work their moisture content shall be 19 percent maximum.

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6. DELIVERY AND STORAGE: Materials shall be delivered to the site in undamaged condition, stored in fully covered, well ventilated areas, without contact with the ground, and protected from extreme changes in temperature and humidity.

7. SAMPLES AND DESCRIPTIVE DATA: The following shall be submitted for approval.

Nails: Four of each kind of nail with description of application for each.

Descriptive data for prefabricated equipment supports.

8. PRESERVATIVE TREATMENT: All wood members shall be preservative-treated by pressure methods and so marked in accordance with the AWPB Standards. Treatment of wood used in conjunction with roofing shall be in accordance with AWPB LP-2. Wood treated with water-borne preservatives shall be air-dried or kiln-dried to the moisture content specified for lumber and marked with the word "Dry". Treated wood which is cut shall be brush-coated with the preservative used in the original treatment.

9. INSTALLATION OF NAILERS:

9.1 Deteriorated portions of existing wood nailers (or plates) shall be removed as directed by the Contracting Officer.

9.1.1 Replaced portion of existing wood nailer shall be secured to existing anchoring devices or if deteriorated new anchoring devices shall be installed.

9.1.2 New anchoring devices shall be secured to existing construction to provide firm anchorage for nailers.

9.2 Installation of nailers for insulation shall be as specified in Section: INSULATION FOR ROOFING.

10. INSTALLATION OF PREFABRICATED EQUIPMENT SUPPORTS:

10.1 Secure to gypsum deck with roofing nails for gypsum deck. Secure through pre-drilled holes in base plate with minimum 4 fasteners per support.

10.2 Secure treated nailer to support with recommended fasteners; minimum 3 per nailer maximum spacing 24 inches on center.

10.3 Install cap flashing and secure to nailer with recommended fasteners with neoprene washers.

10.4 Finished height of support shall be as required to provide proper height for operation of equipment installed there on. Shimming of support unit at roof deck will not be permitted. Shimming will be allowed at nailer only and maximum shim allowed will be 1½ inch and it shall be continuous.

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7. Application of Insulation
8. Wood Nailers

TECHNICAL PROVISIONS

SECTION 7A

1. APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

HH-I-551E
Dated 11 Mar 1974

Insulation Block and Boards, Thermal
(Cellular Glass).

D 312-71 Asphalt for use in Constructing
Built-Up Roof Coverings.

D 2626-73 Asphalt-Base Sheet for Use in
Construction of Built-Up Roofs.

ASHRAE Handbook of Fundamentals (1972).

2.1 Storage of Materials: Insulation and felts shall not be exposed to moisture in any form before, during, or after delivery to the site. Store insulation and felts in an enclosed building or in a trailer. Wet materials shall not be used and shall be removed from the worksite. Felt rolls shall be stacked on end. For 24 hours immediately before laying, materials shall be maintained at a temperature above 50°F. Urthane insulation shall be stored away from areas where welding is being performed or where contact with open flames is possible.

2.2 Preparation Requirements: The roof-deck surface shall be free from ice, frost, and surface moisture and shall be smooth, firm, free from dirt, projections, and foreign materials. Vents and other items penetrating the roof shall be secured in position and properly prepared for flashing. Removal of existing roofing is specified in section: DEMOLITION.

2.3 Application Requirements:

2.3.1 Surfaces shall be inspected and approved prior to application of insulation.

2.3.2 Application of materials shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40°F.

2.3.3 Asphalt shall be used with asphalt-saturated felts. Application and holding temperatures shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers.

2.3.4 Insulation work shall be coordinated with roofing and sheet metalwork so that all material applied each day is waterproofed the same day with the complete roofing system and sheetmetal flashings.

3. SUBMITTALS:

3.1 Certificates of compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the general provisions.

3.2 Computations used for determining insulation thickness shall be submitted for review.

3.3 Temperature Control Equipment: Contractor shall submit manufacturer's literature on the automatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting the recorder, automatic temperature control and portable thermometer were each tested immediately prior to shipment to the site and that all operate within the accuracy tolerance given in the manufacturers specifications. Temperature control and recording equipment shall be in proper working condition during use.

3.4 Samples: The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

Vapor Barrier Membrane - 7 Foot sample from end of each roll used.
Bitumen - 10 pounds of each type used.
Nails, Fasteners and anchors - 1 pound of each type, size and style used.
Insulation - 2-2 foot square samples.

4. MATERIALS shall conform to the following requirements:

4.1 Bitumen: Asphalt: ASTM D 312, Type III.

4.2 Insulation shall be one of the following materials:

4.2.1 Cellular Glass: Fed. Spec. HH-I-551, Type I or IV.

4.2.2 Urethane: Fed. Spec. HH-I-530, Type I, Grade 2, Class 2, Style D.

4.3 Fasteners:

4.3.1 Fasteners designed for nailing to gypsum decks shall be in accordance with the insulation manufacturer's recommendations. Minimum holding power when driven shall be 40 pounds per fastener.

4.3.2 Bolts and nuts shall be semifinished or finished, threaded for medium fit with either hexagonal-shaped or square-shaped nuts and boltheads.

4.3.3 Metal disks shall be flat and not less than 30 gage thickness. Disks used with nails or fasteners for securing fiberboard insulation shall be minimum 1-inch diameter. Disks used with nails or fasteners for securing other board insulation shall be minimum 2-1/8 inch diameter.

4.4 Vapor-Barrier Membrane: Asphalt-Saturated Base Sheet: ASTM D 2626, Type I or II.

5. APPLICATION OF VAPOR BARRIER:

5.1 Over Gypsum Decks: One ply of asphalt-saturated base sheet vapor barrier shall be laid without mopping, at right angles to the direction of slopes. The base sheet shall be laid with not less than 2-inch side laps and 6-inch end laps. End laps shall be staggered. Base sheet shall be nailed 9-inches on center at side laps, and in two rows 11 inches apart down the center of the sheet with nails 18-inches on center staggered.

6. THICKNESS OF INSULATION: The drawings shall not be scaled to determine the required thickness of insulation. Actual installed thickness of insulation shall be such as to provide a coefficient of heat transmission or U-value, through the completed roof construction air-to-air, not in excess of 0.05 BTU per hour, per square foot, per degree F.

temperature difference, when determined for winter conditions in accordance with recognized methods in agreement with ASHRAE Handbook of Fundamentals. Roof construction air-to-air may include finish ceilings, provided unceiling areas do not occur under the same roof area or space above the ceiling is not vented to the exterior. Insulation thickness shall be uniform over common roof areas.

7. APPLICATION OF INSULATION:

7.1 Installation Requirements:

7.1.1 Insulation shall be laid in one or more layers. Units of insulation shall be laid in parallel courses parallel with the roof slope. The end joints shall be staggered. Insulation shall be cut to fit neatly against adjoining surfaces. If installed in more than one layer, joints in successive layers shall be staggered with respect to joints of preceding layer. Insulation which can be readily lifted after installation is not considered to be adequately secured.

7.1.2 Bitumen shall not be applied further than one panel length ahead of roof insulation being installed. The first layer and all successive layers shall be laid in solid moppings of hot bitumen applied at the rate of at least 20 pounds of asphalt. The edges of insulation boards adjoining vented nailers shall be kept free of bitumen. A 1/2-to-1-inch air space shall be provided between parapet walls and insulation for use with wood vents hereinafter specified.

7.2 Protection Requirements: The insulation shall be kept dry at all times and shall be laid just before application of the roofing felts. No more insulation shall be laid than can be covered the same day with the complete roofing system. Exposed edges of the insulation shall be protected by the cutoffs at the end of each day's work or whenever precipitation is imminent. Cutoffs shall be two layers of bituminous-saturated felt set in plastic bituminous cement. Cutoffs shall be removed when work is resumed.

8. WOOD NAILERS: Repair of wood nailers installed flush with the roof deck are specified in SECTION: ROUGH CARPENTRY/FASTENERS AND SUPPORTS. Wood nailers installed on the surface of the roof deck shall be furnished and installed under this section. Nailers shall be treated with water-borne preservative as specified in SECTION: ROUGH CARPENTRY/FASTENERS AND SUPPORTS.

8.1 Edge Nailers: Edge nailers shall be continuous wood members installed at eaves, rakes, and elsewhere as indicated, where insulation is applied on the roof deck. Nailers shall be not less than a nominal 6 inches wide and of thickness to finish flush with the top surface of the insulation. The bottom half of the nailer shall be groove-cut or have scab pieces of lumber secured to the bottom, to provide a net open area equivalent to 10 percent of the edge face for ventilation of the insulation.

8.2 Nailer Securement: Nailers shall be secured to deck materials by not less than 3/8-inch diameter expansion anchors embedded in the deck not over 4 feet on centers. Bolt anchors shall have nuts and washers countersunk, and bolts shall be cut flush with top of nailer. Powder-actuated fasteners, sized and spaced for nailer anchorage equivalent to that specified and indicated, may be used when approved.

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PART I

TECHNICAL PROVISIONS

DIVISION 7

SECTION 7B

BUILT-UP ROOFING

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.1 American Society for Testing and Materials (ASTM) publications:

D 226-77	Asphalt-Saturated Organic Roofing Felt for Use in Membrane Waterproofing and Built-Up Roofing.
D 312-71(R 1977)	Asphalt for Use in Constructing Built-Up Roof Coverings.
D 1863-77	Mineral Aggregate for Use on Built-Up Roofs.
D 2822-75	Asphalt Roof Cement.
D 3617-77	Sampling and Analysis of New Built-Up Roof Membranes.

2. GENERAL: Asphalt bitumen built-up roofing shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage of Materials: Roofing materials shall be delivered to the site in the manufacturer's original unopened containers or wrappers clearly marked to identify contents and manufacturer. Felts and roll roofing shall not be exposed to any moisture before, during, or after delivery to the site. Felts and roll roofing shall be stored in an enclosed building or in a trailer, stacked on end, and maintained above 50 degrees F for 24 hours immediately before laying.

2.2 Coordination Requirements: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations the same day felts are installed. Roofing operations shall also be coordinated with roof insulation work so that all insulation applied each day is waterproofed the same day with the complete roofing system.

2.3 Preparation for reroofing is specified in SECTION: DEMOLITION. Roofs shall be completely weatherproofed at end of each working day.

2.4 Application Requirements: Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. The roofing or flashing shall be applied to a smooth and firm surface free from ice, frost, moisture, dirt, and foreign materials. Application of roofing shall not be performed under damp or wet conditions, excessive wind conditions, or when the ambient temperature is less than 40 degrees F.

2.5 Bituminous-plastic-type flashings installed in accordance with these specifications shall be used throughout unless otherwise specified or indicated. Metal flashings are specified in SECTION: SHEET METALWORK, GENERAL.

3. SUBMITTALS:

3.1 Certificates of Compliance attesting that the materials meet the requirements specified shall be furnished in accordance with the GENERAL PROVISIONS.

3.2 Manufacturers Installation Instructions shall be submitted and approved prior to delivery of materials to the site. Instructions shall specify acceptable range of bitumen application temperatures. Bitumen manufacturer shall specify maximum temperature for holding bitumen in a heated condition.

3.3 Temperature Control Equipment. Contractor shall submit manufacturer's literature on the automatic temperature recorder and automatic thermostatic temperature control intended for use on bitumen kettles and heating tanks. Certificates from an independent testing laboratory shall be submitted attesting that the recorder, automatic temperature control, and portable thermometer were each tested immediately prior to shipment to the site and that all operate within the accuracy tolerances given in the manufacturer's specifications. Temperature control and recording equipment shall be in proper working condition during use.

3.4 Samples. The following samples shall be submitted for independent Government testing; samples shall be taken from the materials delivered to the site.

Felts - 7 ft sample from end of each roll used
Bitumen - 10 pounds of each type used
Bituminous cement - 1 gallon
Surfacing materials - 100 pounds
Nails, fasteners, and anchors - 1 pound of each type, size, and style

4. MATERIALS:

4.1 Asphalt: ASTM D 312 Type I

4.2 Felt shall be the asphalt saturated type and shall conform to the following requirements: Roofing Felt: ASTM D 226, Type I.

4.3 Nails, Fasteners, and Anchors shall be an approved type recommended by the roofing felt manufacturer.

4.4 Roofing Cement: ASTM D 2822, Type I.

4.5 Aggregate for Surfacing: ASTM D 1863, and shall be delivered to work site in bags.

5. ASPHALT BUILT-UP 4-PLY ORGANIC ROOFING:

5.1 Insulation Surfaces: Four plies of roofing felt shall be mopped in solid with hot asphalt. Felts shall be laid shingle-fashion at right angles to the direction of the roof slope and lapped in accordance with Table I. The flashings shall be installed and the flood coat and surfacing applied.

6. APPLICATION OF ROOFING:

6.1 General Requirements: The entire roofing system, including aggregate surfacing, shall be finished in one operation up to the line of termination at end of day's work. Application of roofing shall immediately follow application of insulation as a continuous operation. Phased construction will not be permitted. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen. Completed roof membrane shall be inspected by the Government before aggregate surfacing is applied.

6.2 Detail Requirements:

6.2.1 Mechanical application devices shall be mounted on pneumatic-tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

6.2.2 Bitumen stops formed of edge envelopes shall be installed at eaves and rakes. Envelopes shall be formed of two 18-inch wide layers of roofing felt. Nine inches of the width shall be attached to the roof surface with 9 inches extending beyond the edge. The first layer shall be applied in a 4-inch wide layer of roofing cement and nailed 1/2-inch from the roof edge at 6-inch spacing. The second layer shall be applied to the first in a 9-inch wide mopping of bitumen. The free edges shall be protected from damage throughout the roofing period.

6.2.3 Application and holding temperature shall conform to bitumen manufacturer's recommendations, except that asphalt shall not be heated above 475 degrees F. Overheated bitumen shall be removed from the job site. Heating kettles shall be provided with an automatic charting temperature recorder and automatic thermostatic control. Application temperatures of the bitumen shall be measured on the roof and in the mop bucket and/or mechanical applicator immediately prior to its use, with a portable thermometer. Bitumen with a temperature not conforming to the manufacturer's recommended range of application temperature shall be returned to the kettles and tankers. Each layer of roofing felt shall be laid in not less than 15 pounds of asphalt per square or more than 25 pounds of asphalt per square.

6.2.4 Layers of roofing shall be laid free of wrinkles, creases or fish-mouths, at right angles to the slope of the deck, immediately behind the applicator. The surface of the felts shall be broomed-in full width to obtain complete adhesion between plies and to eliminate air pockets. Brooms shall have soft bristles and shall be discarded when the bitumen build-up on the fiber prevents application of equal pressure across the broom width on felts. The method of mopping a half-sheet width and turning the sheet back to mop under the other half will not be used. Workmen shall not walk on mopped surfaces when the bitumen is sticky. Each layer of roofing felt shall be carried up abutting vertical surfaces at least 4 inches, or to the top of the cant strip. After the last ply of roofing felt is applied, the edge envelope shall be formed by folding back and mopping each layer. The gravel stop, specified in SECTION: SHEET METALWORK, GENERAL, shall be embedded in bituminous cement and nailed on top of the envelope.

6.2.5 Each course of roofing felts, in addition to being mopped in hot bitumen, shall be lapped as specified in Table I.

6.2.6 Nails and fasteners for securing roofing shall be flush-driven through flat metal disks of not less than 1-inch diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 1-inch diameter disks.

6.2.7 At end of each day's work or whenever precipitation is imminent, the terminated edge of built-up roofing shall be sealed with two full width strips of felt set in bituminous cement. Cut insulation pieces shall be temporarily laid in place to straighten the exposed edge of insulation. Extend half-width of strips up and over the finished roofing and extend the other half-width out and onto the bare roof deck surface. Water cutoffs and temporary insulation pieces shall be removed before continuing installation of roof system.

7. FLASHINGS: Flashings shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous-plastic-type flashings described below shall be used, except where metal flashings are indicated or specified in SECTION: SHEET METALWORK, GENERAL. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends.

7.1 Base Flashings: Materials and installation shall be in accordance with the approved recommendations of the roofing felt manufacturer. Base flashings shall consist of one ply of asbestos felt and one ply of a reinforced asbestos flashing sheet as the outer ply.

7.2 Strip Flashings: Roof flanges of lead and sheetmetal flashings, such as gravel stops, base flashings, and plumbing flashings, furnished and installed under other sections of the specifications, shall be stripped with two layers of roofing felt set in plastic cement. After installation of flanges of flashings over the top ply of roofing, the strip flashings, consisting of two layers of roofing felt, 9 and 12 inches wide, shall be successively cemented to the top of the roof flange using bituminous plastic cement, to form a waterproof joint between roofing and flashings.

7.3 Sleeve-Type Bitumen Stops shall be installed at all pipe and conduit roof penetrations. Sleeve shall be 3 inches high; flange shall be 3 inches wide. Flange of bitumen stop shall be placed on the insulation below the roofing membrane. Bitumen stops shall be made of copper and nailed in place as specified in SECTION: SHEET METALWORK, GENERAL.

8. SURFACING: Contractor shall determine the moisture content of a representative sample of the surfacing material as determined by the Contracting Officer. If materials are found with excessive moisture contents, the materials shall be dried on the site to meet ASTM D 1863 specifications. After roofing felts have been laid and flashings installed, the roof surface, except for cants, shall be flood coated uniformly with 60 pounds of asphalt per square. While bitumen is still hot, 400 pounds per square of roofing aggregate shall be embedded therein. Aggregate shall be placed in the manner and quantity required to form a compact embedded overlay. Roof surface shall be swept and all loose aggregate removed. Flood coat and aggregate shall be applied the same day as the felts are laid. If there is a probability of rain falling on the felts before the flood coat and aggregate can be applied, a light glaze coat of bitumen, 10 to 15 pounds per square, shall be applied over the exposed felts. The glaze coat may be considered as part of the flood coat provided the surfacing operation is completed within 48 hours after application of the glaze coat. Where glaze coat is used, surface treatment shall be completed as soon as weather conditions permit.

9. QUALITY ASSURANCE:

9.1 Reverification of Temperature Controls: Contractor shall verify the accuracy of the temperature recorder each work day before using bitumen from kettle or tanker using a portable thermometer.

9.2 Charts and Records. Contractor shall provide daily the chart from the temperature recorder and evidence that the recorder accuracy was verified.

9.3 Application Temperatures: Contractor shall furnish a daily record indicating the application temperature of each bucket of bitumen accepted on the roof.

9.4 Roof Cutout Samples: Roof sampling shall comply with ASTM D 3617 except that one sample shall be taken for each 10 square (1000 square feet) of roofing, and also as directed by the Contracting Officer when there is reason to believe that deficiencies exist. Sample dimensions shall be 4 inches by 36 inches. Length of sample shall be taken across the felts. The Government will test the sample for head laps, weight, free water, and existence of voids. The hole in the roofing membrane shall be flooded with hot bitumen, and a new section of equivalent size and structure shall be built in the hole. The sample area shall be covered with 3 plies of felt, hot mopped in place with the first ply overlapping the sample area 3 inches on all sides and each succeeding ply overlapping the preceding 3 inches on all sides.

If the sample indicates a deficiency, the Contractor shall take additional samples to determine the extent of the deficiency. Deficient roofing shall be removed and replaced. A sample shall be taken from replaced roofing.

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TABLE I
LAPS FOR ROOFING FELTS

Layers or plies	Laps in inches for 36-inch width	Starting widths in inches for 36-inch width
1	4	36
3	24-2/3	12, 24 and 36
4	27-1/2	9, 18, 27, and 36

PART I
TECHNICAL PROVISIONS
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SECTION 7C
ELASTOMERIC ROOFING (EPDM)

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PART I

TECHNICAL PROVISIONS

DIVISION 7

SECTION 7C

ELASTOMERIC ROOFING (EPDM)

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1 American Society for Testing and Materials (ASTM) Publications:

D 692-71

Coarse Aggregate for Bituminous
Paving Mixtures.

D-3253-77

Vulcanized Rubber Sheetting for Pond,
Canal and Reservoir Linings.

2. GENERAL: Loose-laid with ballast Ethylene Propylene Diene Monomer (EPDM) roofing shall be applied to the roof surfaces indicated. Roofing membrane shall be furnished in the largest sheets possible to minimize joints. All materials used for the roofing system shall be the products of a single manufacturer. Membrane shall be free of any pinholes, lumps and foreign material.

2.1 Standard Products: The EPDM roofing system including flashing shall be the standard product of a single manufacturer regularly engaged in the production of this type of product.

2.2 Delivery and Storage: Materials shall be delivered to the job site in the manufacturer's original, unopened packages, clearly marked with the manufacturer's name, brand name, and description of content. Materials shall be stored in clean, dry areas at a temperature between 60 degrees F and 80 degrees F.

2.3 Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous-roof surfacing operations. Roofing operations shall also be coordinated with roof insulation so that all insulation applied each day is weatherproofed the same day with the completed roofing system.

2.4 Preparation for Reroofing: Preparation for reroofing is specified in SECTION: DEMOLITION. Roofs shall be completely weatherproofed at end of each working day.

3. SUBMITTALS: Contractor shall submit the following in accordance with the GENERAL PROVISIONS:

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3.1 Certificates of Compliance attesting that the materials meet specifications requirements.

3.2 Qualifications of Installer: Certificate from manufacturer identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's Instructions: for installation of the membrane, including procedures for preparing the membrane for use, flashing, splicing and use of prefabricated pipe sleeves for smoke testing, and smoke testing procedures.

3.4 Samples of Membrane Materials and Aggregate shall be submitted for testing by the Government. A 1-ft wide, full width sample shall be furnished from the end of each piece of EPDM membrane placed on the roof. In addition, 200 square feet of representative samples of the EPDM membrane used shall be furnished. An 18-inch long by 12-inch wide sample of the seam formed by connecting adjacent sheets of EPDM membrane shall be furnished from the first 100 feet of seam constructed plus an additional sample the same size from each additional 300 feet of seam constructed. In addition, 20 feet of seam 1-ft wide formed by connecting two sheets of EPDM shall be furnished. One quart of each bonding adhesives one cartridge of sealant, 100 lbs. of ballast, and 1 lb. of fasteners shall also be furnished.

3.5 Shop Drawings showing the size of sheets, position of sheets and splices, flashing details, and nailing of sheets.

4. MATERIALS:

4.1 Membrane shall be .045 inch thick, and shall comply with ASTM D 3253, Type II, except as follows:

PROPERTY	VALUE
Tensile Strength	1400 psi min
Tear Resistance	125 lb/in min
Heat Aging (Accelerated) Elongation	210% min
Brittleness	-50°F min
Ozone Resistance	No Cracks
Permeability, Water Vapor	2.0 perm-mils

4.2 Adhesives: Cements and sealants shall be of types recommended by the roofing membrane manufacturer.

4.3 Wood nailers shall be number 2 or better grade lumber and shall

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be water-borne preservative treated as specified in SECTION: ROUGH CARPENTRY/FASTENERS AND SUPPORTS.

4.4 Insulation shall be Urethane or Cellular Glass board insulation as specified in SECTION: INSULATION FOR BUILT-UP ROOFING.

4.5 Fasteners: Nails and fasteners used with flashing, nailers, and insulation shall be of the types and sizes best suited for the job and shall comply with roofing manufacturer's approved instructions.

4.6 Ballast shall be smooth, water-washed round stone approximately 3/4 to 1-1/2 inch diameter with gradation complying with ASTM D 692, Size 4. Ballast shall be delivered to work site in bags.

4.7 Flashing shall be of durable elastomeric material compatible with the membrane specified, as furnished by the roofing manufacturer.

4.8 Prefabricated Accessories such as pipe seals shall be of types and sizes recommended by the roofing membrane manufacturer.

5. INSTALLATION. Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

5.1 Nailers shall be installed on the perimeter of roof surfaces, curb flashing, and similar penetrations, as specified in SECTION: ROUGH CARPENTRY/FASTENERS AND SUPPORTS.

5.2 Insulation shall be placed completely covering the roof. Insulation shall be fastened with hot asphalt in accordance with SECTION: INSULATION FOR BUILT-UP ROOFING.

5.3 Membrane shall be sealed to adjoining sheets using minimum 3 inch wide laps. Direction of lap shall be such that water flows over lap. Wrinkles shall not extend into terminations or field splices. Prefabricated pipe sleeves for smoke testing shall be installed where indicated.

5.4 Splices: Mating surfaces shall be cleaned with heptane, or with unleaded or white gasoline. Splice edges shall be cleaned of adhesive with solvents and sealed.

5.5 Perimeter Nailing: Membrane shall be mechanically fastened to all nailers using roofing nails.

5.6 Flashing: All projections and changes in roof planes shall be flashed. The splice between the flashing and the main roof sheet shall be completed before bonding the flashing to the vertical surface. The splice shall be sealed a minimum of 3 inches beyond the fasteners which attach the membrane to the horizontal nailer. The installed flashing shall be nailed at the top of the flashing a maximum of 12 inches on center under the metal counter-flashing or cap. Factory prefabricated pipe seals shall be used to flash all pipe where installation is possible.

5.7 Ballast shall be applied in a minimum 10 pounds per square foot layer over completed membrane. Membrane shall be protected from mechanical damage during ballast application. Ballast shall not be stockpiled on roof deck.

5.8 Cut-Offs: If work is terminated prior to weatherproofing the roof, the insulation line shall be straightened using loose-laid cut sheets and the membrane shall be sealed to the roof deck. Membrane shall be pulled free or cut to expose the insulation when resuming work and cut insulation sheets used for fill-in shall be removed.

6. INSPECTION: All joints shall be inspected over entire length after completion and all defective areas resealed before ballast is installed. Damaged areas of membrane shall be removed and recovered, lapping underlying membrane by at least 3 inches on all sides. The roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications. Contractor shall submit the certificate to the Contracting Officer. Contractor shall conduct smoke tests in compliance with manufacturer's approved instructions before ballast is installed. Leaks shall be repaired at the contractor's expense.

PART I
TECHNICAL PROVISIONS
DIVISION 7
SECTION 7D
ELASTOMERIC ROOFING, FLUID APPLIED

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PART I

TECHNICAL PROVISIONS

DIVISION 7

SECTION 7D

ELASTOMERIC ROOFING, FLUID APPLIED

1. APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1 American Society for Testing and Materials (ASTM) Publications:

C 177-76	Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate
D 312-71 (R1977)	Asphalt for Use in Constructing Built-Up Roof Covering
D 1621-73	Compressive Properties of Rigid Cellular Plastics
D 1622-63	Apparent Density of Rigid Cellular Plastics
D 2626-73	Asphalt-Base Sheet for Use in Construction of Built-Up Roofs
D 2822-75	Asphalt Roof Cement
E 96-66 (R1972)	Water Vapor Transmission of Materials in Sheet Form

1.2 Factory Mutual Corporation (FM) Publications: Approval Guide, Equipment, Materials, Services for Conservation of Property.

1.3 Underwriters Laboratories, Inc. Publications:

UL 790	Tests for Fire Resistance of Roof Covering Materials
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2. GENERAL: The roofing system shall consist of a layer of sprayed-in-place urethane foam roof insulation covered with a two-coat elastomeric coating. The system shall be applied to the roof surfaces indicated.

2.1 Delivery and Storage: Materials shall be delivered to the job site in their original unopened packages, clearly marked with the manufacturer's name, brand name, and description of contents. Materials shall be stored in clean and dry areas.

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2.2 Coordination: Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations.

2.3 Preparation: Surfaces shall be dry and free of loose coatings or other contaminants. Workmen shall wear clean, soft-soled sneaker-type shoes.

2.4 Preparation For Reroofing:

2.4.1 Removal of roofing is specified in Section: DEMOLITION.

2.4.2 Cleaning: Prepared roof area shall be cleaned with compressed air using three passes, each at a right angle to the preceding one. Last pass shall be made immediately prior to application of new roofing system. Debris accumulated shall be dumped down the chute. Contractor shall prevent the loss of debris around the perimeter of the building.

2.4.3 Protection: The roof shall be completely weatherproofed at the end of each work day. Removal activities shall be limited to that area which can be reroofed during the same day.

2.4.4 Priming: After cleaning, roof surfaces shall be primed at an application rate recommended by the roofing manufacturer.

2.5 Over-Spraying: Contractor shall construct barriers or take other measures to prevent overspraying and shall be responsible for damages resulting from overspraying.

3. SUBMITTALS: The following shall be submitted in accordance with the GENERAL PROVISIONS:

3.1 Certificates of Compliance attesting that the materials meet the specification requirements, and certificate from coating manufacturer certifying that coating and foam system being supplied has been tested and meets the requirements of UL 790.

3.2 Qualifications of Installer: Certificate from the foam and coating manufacturers identifying the installer and certifying that the installer is qualified to install the roofing system.

3.3 Manufacturer's Instructions for installation of the foam and coating roofing system.

3.4 Samples shall be submitted as follows for independent Government testing:

Each component of foam and protective coating	5 gallon container
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Granules	10 pounds
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Primer	1 gallon
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Sealant	1 cartridge
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Foam with coating	2 samples (2 ft x 2 ft)
Foam with coating and wearing course	1 sample (2 ft x 2 ft)
Walk surface	1 sample (2 ft x 4ft)

4. MATERIALS:

4.1 Urethane Foam: Cured foam shall conform to the following properties:

PROPERTY	TEST METHOD	VALUE
Density, lb/ft ³ overall	ASTM D 1622	2.7 min., 3.5 max.
Compressive Strength, psi parallel to rise	ASTM D 1621	40.0 min.
Thermal Conductivity (K factor) Btu/hr/ft ² / °F/in	ASTM C 177	new 0.11 max. aged 0.15 max.

4.2 Protective Coating System shall be one of the following permeable types with a maximum perm rating of 3.5 when tested as specified in ASTM E 96, procedure B.

4.2.1 Silicone Weather Coating, manufactured by General Electric Company (medium gray base coat SCM 3308/501C and cement gray top coat SCM 3304/3307C).

4.2.2 Silicone 3-5000 Construction Coating manufactured by Dow Corning Company (light gray base coat and white top coat).

4.2.3 Catalyzed urethane, IRATHANE Weather/Flex Plus manufactured by Irathane Systems (urethane base coat of IRATHANE 300 and a hypalon top coat of IRATHANE 157).

4.3 Granules: No. 11 screen size, ceramic coated, in colors provided by the manufacturer.

4.4 Roofing Felt: ASTM D 2626, Type I.

4.5 Primer and Sealer shall be of the type recommended by the coating manufacturer.

4.6 Asphalt: ASTM D 312, Type III.

4.7 Walk Surface: Glass fiber woven into mats. Uncoated.

5. INSTALLATION: Installation shall comply with the manufacturer's approved instructions, except as otherwise specified.

5.1 Base Sheet: Shall be one layer of roofing felt mopped in full width, using four inch side laps and six inch end laps. Asphalt shall be applied at a rate of 23 pounds per square and felts shall be broomed in full width.

5.2 Urethane Foam shall be sprayed on the prepared deck to a minimum thickness of one inch except where variations are needed to ensure drainage. Foam shall be applied in 1/2 inch lifts. Time between lifts shall not exceed 4 hours. The finished surface shall be smooth and free of voids, crevices, and pinholes. Foam with surface condition known as "tree bark" or "popcorn" shall be removed and replaced at the contractor's expense. Foam shall be extended up walls and around roof projections to form cant and flashings that terminate at least 2 inches above finished roof surface. Foam shall be cured and free from water, dust, oils, and other materials which would impair adhesion of coating. No foam shall be allowed to stand overnight without a base protective coating. Foam shall cure at least one hour before application of protective coating.

5.3 Protective Coating: Coating shall be applied and cured in accordance with manufacturer's instructions. Coating shall consist of a base coat and top coat. Base coats exposed for more than 24 hours shall be cleaned with a detergent solution, rinsed thoroughly, allowed to dry, and recovered with base coating.

5.3.1 Base Coat shall have a minimum dry thickness of 10 mils for silicone, or 15 mils for Isathane. Coating shall completely cover the foam and extend up vertical surfaces 2 inches beyond foam. Coating shall be dry and clean before application of top coat.

5.3.2 Top Coat shall be applied at right angles to the direction of the base coat application. Total dry film thickness shall be 20 mils minimum. Film thickness shall be verified by taking samples as specified below. Sample areas shall be recoated to restore film. Foam with "orange peel" or "coarse orange peel" surfaces shall have additional coating applied as required to obtain minimum dry film thickness.

5.4 Flashing: Areas to be flashed shall be dry and free from all dust, dirt, tar, oils, and other debris. Metal surfaces shall also be free from all rust. Termination points requiring flashing shall be caulked with manufacturer's recommended sealant. Coating shall then be applied at a rate of 1 gallon per 100 square feet to an area a minimum of 4 inches on either side of the sealant. After flashing system has cured, 2 additional coats shall be applied to flashing areas during normal coating operations.

5.5 Granules: Granules shall be applied within 5 minutes of top coat application, using pressure equipment, at a rate of 50 lbs per 100 square feet. Granules shall be applied in a minimum of 2 passes at right angles. Finished granule systems shall be uniform over entire surface with no apparent void areas. No traffic shall be allowed on finished area for 24 hours after granule application is completed.

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5.6 Service Walks: Service walks shall be applied after the 2-coat system has been completed and cured. Reinforcing fabric 24 to 48 inches wide and as standard with the coating manufacturer shall be set into a third layer of the coating and smoothed with brush or roller. Fabric shall then be coated with the base coating to a minimum of 6 inches beyond each edge, completely covering the fabric so that none of it is exposed. No traffic shall be allowed in the area for 48 hours after installation.

6. EQUIPMENT CALIBRATION: Spray equipment for two-component systems shall be calibrated each day at start of operations, each restart if spraying operations have been terminated for more than one hour, if there is a change in fan pattern, change in pressure, slow curing areas are noticed, change in work area requiring a change in hose length or in working height, after changing or cleaning filter elements, after changing curing agents, after changing between protective coatings, and whenever directed by the Contracting Officer. Calibration shall consist of demonstrating that the equipment is adjusted to deliver components in the proportion and at rate specified in approved manufacturer's instructions. Calibration tests shall be accomplished on the roof adjacent to the area to be sprayed.

7. CONTROL SAMPLES: Immediately following satisfactory completion of each calibration procedure, the contractor shall collect samples as specified below. The date, time of day, and material identification of each sample layer shall be clearly marked.

7.1 Foam: Contractor shall prepare wooden open-top boxes 24-inches square by depth of finished roof section. Boxes shall be filled in 1/2-inch lifts during actual roof foaming, each lift being collected at the same time it is applied to the roof.

7.2 Protective Coating: Samples shall be collected after each calibration and at least once per ten squares of application in a continuous operation. Contractor shall place two Government furnished test plates in path of spray operations, remove them after being sprayed, and respray areas to repair coating. Wet thickness shall be determined from one plate; if deficient, the contractor shall be directed to take corrective action. The 24-inch square foam samples shall be coated in the same manner.

7.3 Wearing Course: One of the 24-inch square samples shall consist of the completed roof system including wearing course.

8. INSPECTION: Foam surface will be inspected for texture, blisters, non-adherence to substrate, and other defects before finish coating is applied. All pinholes shall be finished flush with sealant recommended by the coating manufacturer. Roofing manufacturer shall certify that the completed roofing system conforms to approved installation instructions and these specifications.

PART I
TECHNICAL PROVISIONS
DIVISION 7
SECTION 7E
SHEET METALWORK, GENERAL

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PART I

TECHNICAL PROVISIONS

DIVISION 7

SECTION 7E

SHEET METALWORK, GENERAL

1. APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

1.1 Federal Specifications:

Q-F-506C Dated 15 Feb 72	Flux, Soldering; Paste and Liquid.
QQ-S-571E Dated 16 Jul 75	Solder; Tin Alloy; Lead-Tin Alloy; and Lead Alloy.
SS-C-153C Dated 13 Dec 74	Cement, Bituminous, Plastic.

1.2 American Society for Testing and Materials (ASTM) Publications:

B 36-77	Brass Plate, Sheet, Strip, and Rolled Bar.
B 370-77	Copper Sheet and Strip for Building Construction.

2. GENERAL: Sheet metal items shall be fabricated to the thickness or weight shown in table I and multiple lengths of items shall be joined together as shown in table II. Surfaces that are to receive sheet metal and underlayments shall be even, smooth, sound, thoroughly clean and dry, and free from defects that might affect the application. Sheet metal items shall be furnished in 8- to 10-foot lengths. Single pieces less than 8 feet long may be used to connect to factory fabricated inside and outside corners, and at ends of runs. Cutting, fitting, drilling, and other operations in connection with sheet metal required to accommodate the work of other trades shall be performed by sheet metal mechanics. Accessories and other items essential to complete the sheet metal installation, though not specifically indicated or specified shall be provided. Where sheet metal abuts or extends into adjacent materials, the juncture shall be executed in a manner to assure weathertight construction. Roof flanges of sheet metal shall be set in plastic bituminous cement over built-up roofing. Application of bituminous strip flashing over roof flanges for various sheet metal items is covered in ROOFING SECTIONS. Installation of sheet metal items used in conjunction with roofing, such as gravel stops, shall be coordinated with roofing work to permit continuous roof surfacing operations. Factory fabricated components such as flashings, gutters,

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downspouts, and gravel stops shall be packed in cartons which are marked with the manufacturer's name or trademark. Bulk materials from which items are field fabricated shall have manufacturer's name or trademark printed or embossed at frequent intervals to permit easy identification.

3. SHOP DRAWINGS showing complete erection layouts, details, and installation instructions shall be submitted for approval in accordance with the GENERAL PROVISIONS. Materials shall not be delivered to the site until after the approved shop drawings have been returned to the Contractor. Details and layouts shall show weights, gages, or thicknesses of sheet metal, joining, expansion-joint spacing, and procedures to be followed during installation. The Contractor shall be responsible for any errors of detailing and fabrication and for the correct fitting of sheet metal-work shown on the shop drawings. Scaled catalog cuts may be submitted for factory fabricated items. Shop drawings shall be provided for the following items:

Gutters.

Gravel stops and fasciae.

Flashings at roof penetrations.

4. MATERIALS shall conform to the respective specifications and other requirements specified below:

4.1 Sealing compound: Sealing compounds referred to herein are specified in SECTION: CALKING AND SEALANTS.

4.2 Copper: ASTM Specification B 370, sheet and strip, light cold-rolled temper, except where otherwise indicated.

4.3 Fastening materials not specified for a particular sheet metal application shall be of the type best suited for the intended purpose. Nails shall be barbed, annular thread or screw type. Nails, rivets, screws, bolts and nuts used for fastening plain copper shall be bronze, brass or copper. Stainless steel fastenings shall be used for connecting dissimilar metals.

4.4 Bituminous Plastic cement: Federal Specification SS-C-153, type I with asphalt roofing felts.

4.5 Solder shall conform to Federal Specification QQ-S-571, composition Sn50 for copper.

4.6 Soldering flux shall be Federal Specification O-F-506, type I, form A or B.

5. EXPOSED SHEET METAL: The following items shall be considered as exposed sheet metal: gutters including hangers, downspouts and leaders, downspout heads, gravel stops and fasciae, cap, flashings.

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6. TYPES OF JOINTS: Joints consist of locked, lapped, butt, riveted, and soldered types. Table II herein indicates the types of joints to be used and the sealants required. Unless otherwise specified, sealants are covered in SECTION: CALKING AND SEALANTS.

7. FASTENINGS for copper shall be specified in subparagraph Fastening materials under paragraph MATERIALS.

7.1 Nailing of sheet metal shall be confined generally to sheet metal having a width of less than 18 inches. Nailing of flashings shall be confined to one edge only. Nails shall be evenly spaced not over 3 inches on centers and approximately 1/2 inch from edge unless otherwise specified or indicated.

7.2 Cleats shall be provided where specified or required and shall be evenly spaced not over 12 inches on centers unless otherwise specified or indicated. Unless otherwise specified cleats shall be not less than 2 inches wide by 3 inches long and shall be of the same material and thickness as the sheet metal being installed. One end of the cleat shall be secured with two nails and the cleat folded back over the nailheads. The other end shall be locked into the seam. Cleats for soldered seams shall be pretinned.

7.3 Bolts, rivets, and screws shall be installed where indicated or required.

8. SOLDERING, RIVETING, SEAMING, AND SEALING: Where soldering is specified herein it shall apply to copper items.

8.1 Soldering: Edges of sheet metals shall be tinned before soldering is begun. Soldering shall be done slowly with well heated soldering irons so as to thoroughly heat the seams and completely sweat the solder through the full width of the seam. Soldering shall follow immediately after application of the flux. Upon completion of soldering the acid flux residue shall be thoroughly cleaned from the sheet metal with a solution of washing soda in water and rinsed with clean water.

8.2 Sheet metal to be repaired shall be thoroughly cleaned prior to soldering.

8.3 Seams shall conform to the following requirements:

8.3.1 Flat-lock seams shall finish not less than 1 inch wide.

8.3.2 Soldered-lap seams shall finish not less than 1 inch wide.

8.3.3 Unsoldered plain-lap seams shall lap not less than 3 inches unless otherwise specified.

8.3.4 Flat seams shall be made in the direction of the flow.

9. SAMPLES AND CERTIFICATES:

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9.1 Samples of materials proposed for use shall be submitted to the Contracting Officer for approval.

9.2 Certificates of compliance with specification requirements shall be submitted in accordance with GENERAL PROVISIONS.

10. HANDLING AND STORAGE: Sheet-metal items shall be carefully handled to prevent damage to the surfaces, edges, and ends, and shall be stored at the site above the ground in a covered, dry location. Damaged items that cannot be restored to like-new condition will be rejected and shall be replaced at no additional cost to the Government.

11. DOWNSPOUTS AND LEADERS:

11.1 Downspouts and leaders shall be factory fabricated rectangular, longitudinally corrugated type, with flat locked seams. Downspouts shall be set plumb and not less than 1 inch from wall. Elbow fittings shall be used to make connections with downspout and eave tube. Rivet spacing shall be not more than 2 inches. Strainer shall be set loosely in the eave tube opening in gutter. Joints between lengths of downspouts shall be made by telescoping the end of the upper lengths at least 3/4 inch into the lower length.

11.2 Downspout termination: Downspouts terminating at grade shall be provided with stock elbow-type fittings.

11.3 Downspout Straps: One strap shall be provided adjacent to the joint at the top of each section of downspout except that the bottom section shall have an additional strap adjacent to the bottom joint. Strap shall be a two-piece device consisting of inner and outer flap bottom U-shaped pieces. The legs of the inner piece shall be flanged outward at least 2 inches with holes for anchor bolts located in center of flanges. Formed depth of inner piece shall be sufficient to provide 1-inch clearance from downspout to wall, and each side of this piece shall have a hole slotted horizontally, and sized to fit a bolt fastened through the outer piece. The outer piece shall fit over the downspout and shall be fastened to the inner piece in such manner as to hold the downspout firmly in position. The device shall have an inside width equal to the downspout width plus 1/16 inch. The inner piece shall be secured to masonry and leg screws or bolts 1/4-inch by 1 1/2-inches long in expansion anchors. Bolts for fastening the two pieces together shall not be less than 3/16-inch diameter by 5/8 inch long. Bolts or leg screws shall be compatible with the metal being fastened.

12. GUTTERS: Gutters shall be rectangular type. The rear side of the gutter shall be not less than 1/2 inch higher than the opposite side. Openings in gutters shall have outlet tubes flanged, locked and riveted, or soldered to gutters. Outlet tubes shall conform to the size and shape of the downspouts and shall extend not less than 1-1/2 inches into downspouts. Outer edge of gutter shall be box type design to permit slip type interlocking strap hanger. The top edge of the rear face of the gutters shall be folded back to form a continuous hook not less than 1/2 inch deep. The gutter

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shall be supported by a continuous cleat of not less than 2 1/2 inches wide running the full length of the gutter. Continuous cleat shall be anchored to the structure at spacings not exceeding 16 inches and aligned to provide a 1/16-inch per foot slope to the gutter. Gutters shall have strap hangers, fastened to roof nailer by screw shank-type nails and interlocking with leading edge of gutter. Strap hangers shall be of sufficient length so that when positioned on roof shall extend from leading edge of gutter to at least 2 inches out on the roof. Suitable V-crimp shall be provided over gravel stop. Portion of strap hanger on roof shall be set in plastic bituminous cement and strip flashed with strips on roofing felt specified in ROOFING SECTIONS. Strap hangers shall be spaced at not more than 36 inches on centers. Interlocking feature of hanger with gutter shall be such as will permit expansion and contraction movement of the gutter. Roof portion of strap hanger shall be nailed with screw type nails into wood deck or wood nailer. Gutter shall be hung with high points equidistant from downspouts and shall have a slope of not less than 1/16 inch per foot. Joints shall be made as hereinbefore specified. Gutter expansion joints shall be spaced as required by paragraph Expansion and Contraction joints for sheet metal. Expansion joints shall provide at least a 1-inch space between end baffles of gutters, which space shall be closed with a cover plate having a loose-locked slip joint conforming to the gutter manufacturer's recommendation. Cover plate shall conceal the 1-inch space between gutter faces and bottom of gutters. Top cover plate shall include a V-shaped upstanding piece to divert runoff into gutters. At expansion joints the gutter sections may be overlapped at least 3 inches before the end baffles are located in lieu of installing the side and bottom cover plate.

13. Expansion and contraction joints for sheet metal shall be provided at 40-foot intervals for copper, except that where the distance between the last expansion joint and the end of the continuous run is more than half the required interval spacing an additional joint shall be provided. Joints shall be evenly spaced.

14. Flashings shall be installed or repaired as indicated at intersections on roof with vertical surfaces and at projections through roof.

14.1 Ends of cap flashings shall be sealed with No. 2 or 4 sealant.

14.2 Lap joints in existing copper cap flashing shall be cleaned and resoldered.

14.3 Remove face nails from existing copper cap flashing and cover holes with copper patch soldered in place.

14.4 All repairs or new material installed shall be watertight.

15. A continuous cleat strip shall be provided where indicated or specified to secure loose edges of the sheet metalwork. Butt joints shall be spaced approximately 1/8-inch apart. The strip shall be fastened to the support-

ing construction with nails evenly spaced not over 12 inches on centers. Where the fastening is to be made to concrete or masonry, screws shall be used and shall be driven in expansion shields set in concrete or masonry. The strip fascia anchorage shall be installed to extend below the supporting construction to form a drip and to allow the flashing to be hooked over the lower edge at least 3/4 inch. The strip shall be of sufficient width to provide adequate bearing area to insure a rigid installation. Where horizontal nailer is vented for insulation and strip is placed over masonry or concrete the strip shall be installed over 1/16 inch thick metal washers placed at screws. Washers shall be of metal that is electrolytically compatible with the edge of strip.

16. GRAVEL STOPS AND FASCIA shall be provided for roof edges. Sheets shall be fabricated without longitudinal joints. Provision for expansion shall be provided at joints. Factory fabricated internal and external corner units with mitered joints shall be provided. Roof flange and splice plate of the gravel stop and fascia shall extend out on the roof not less than 4 inches, and shall be set in plastic bituminous cement over the roofing felt. Roof flange shall be nailed with nails spaced not greater than 3 inches on centers located within 1 inch of the outer edge of the flange. The fascia section shall not be face nailed. The lower piece shall be hooked 1/2 inch over edge strip and splice plate and face nailed on 12-inch centers 1 inch below top of sheet. The upper fascia shall be hemmed 1/2 inch at lower edge and shall be formed to fit tight against lower fascia.

16.1 Sheets, smooth: Joining shall be as specified in table II. Gravel stops shall be installed with 1/2 inch space between sections. The joint shall be covered with a 6-inch wide cover plate formed to the profile of the gravel stop. The cover plate shall be embedded in mastic, nailed through the opening between the gravel stop sections and loose locked to the drip edge. The lower edge of fascia shall be hooked 3/4 inch over an edge specified in paragraph CONTINUOUS CLEATS. The lower hooked edge shall be bent outward at an angle of 30 degrees.

17. PAINTING: Sheet metalwork shall not be field painted.

TABLE I
SHEET METAL WEIGHTS, THICKNESSES, AND GAGES.

<u>Item Description</u>	<u>Copper ounce per square foot</u>
Covering on minor flat pitched or curved surfaces	20
Downspouts and leaders	16
Downspout straps, 2-inch(a)	48
Strainers, wire diameter of gage	No. 9 gage
Flashings:	
Base	20
Cap	16
Miscellaneous	16
Gravel stops and fasciae Sheets, smooth	20
Continuous Cleats, 1-1/4-inch width	24
Gutters:	
Gutter section	16
Continuous cleat	16
Hangers, dimensions	1"x1/8"(a)
Cover plates	16

(a) Brass

TABLE II
SHEET METAL JOINTS, (Continued)

<u>Item Description</u>	<u>Type of Joint</u> <u>Copper</u>	<u>Remarks</u>
Gravel stops:		
Sheet, smooth	Butt with 1/2 inch space	Use 6-inch cover plate.
Gutters	1 1/2 inch lap, riveted and soldered	

7E-8

PART I
TECHNICAL PROVISIONS
DIVISION 7
SECTION 7F
CALKING AND SEALANTS

INDEX

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PART I

TECHNICAL PROVISIONS

DIVISION 7

SECTION 7F

CALKING AND SEALANTS

1. APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

1.1 Federal Specifications (Fed. Spec.):

TT-S-00227E
& Am 3
Dated 09 Oct 70

Sealing Compound: Elastomeric Type,
Multi-Component (For Calking, Sealing,
and Glazing in Buildings and Other
Structures).

TT-S-00230C
& Am 2
Dated 09 Oct 70

Sealing Compound: Elastomeric Type,
Single Component (For Calking, Sealing,
and Glazing in Buildings and Other
Structures).

TT-S-001543A
Dated 09 JUN 71

Sealing Compound: Silicone Rubber Base
(For Calking, Sealing, and Glazing in
Buildings and Other Structures).

2. GENERAL: Calking or sealant shall be provided in joints as indicated or specified. The joint design, shape, and spacing shall be as indicated. Mixing shall be in accordance with instructions provided by the manufacturer of the sealants.

3. SUBMITTALS:

3.1 Certificates of Compliance: Certificates of compliance stating that the sealants conform to the specified requirements shall be submitted in accordance with the GENERAL PROVISIONS. Certified laboratory test reports showing that the sealants have been tested within the last 12 months and meet the requirements of the applicable specification shall be submitted.

3.2 Descriptive Data: Manufacturer's descriptive data including backstop material, primer and sealer shall be submitted for approval. Descriptive data for elastomeric sealants shall include shelf life, curing time, and mixing instructions for two component sealants.

3.3 Samples: One cartridge or equivalent representative sample of each sealant specified herein shall be submitted for approval.

7F-01

4. ENVIRONMENTAL REQUIREMENTS: The ambient temperature shall be within the limits of 40 and 90 degrees F. when the sealants are applied.

5. DELIVERY AND STORAGE: Materials shall be delivered to the job in the manufacturer's containers. Materials shall be carefully handled and stored to prevent inclusion of foreign materials or exposure to temperatures exceeding 90 degrees F.

6. MATERIALS: Materials shall conform to the respective specifications and other requirements specified.

6.1 No. 2 Sealant: No. 2 sealant shall be a two-component, elastomeric-type compound conforming to TT-S-227, Type II, Class A. The compound shall be supplied in pre-measured kit form for on-the-job mixing.

6.2 No. 4 Sealant: No. 4 sealant shall be a one-component, elastomeric-type compound conforming to TT-S-230, Type II, Class A or TT-S-1543, Class A.

7. PRIMER: Primer for No. 2 sealant shall be as recommended by the sealant manufacturer. Primer shall have been tested for durability with the sealant to be used and on samples of the surfaces to be sealed.

8. BACKSTOP MATERIAL: Backstop material shall be resilient urethane or polyvinyl-chloride foam, closed-cell polyethylene foam, closed-cell sponge of vinyl or rubber extrusions. Backstop material shall be nonabsorbent, non-staining, and compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

9. BOND-PREVENTIVE MATERIALS: Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminum foil. At the option of the Contractor, backstop material with bond breaking characteristics may be installed in lieu of bond-preventive materials specified.

10. SURFACE PREPARATION:

10.1 General: The surfaces of joints to be sealed shall be dry. Oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale, and other foreign substances shall be removed from all joint surfaces to be sealed. Oil and grease shall be removed with solvent and surfaces shall be wiped with clean cloths.

10.2 Metal Surfaces: Steel surfaces to be in contact with sealant shall be sandblasted or, if sandblasting would not be practical or would damage adjacent finish work, the metal shall be scraped and wire brushed to remove loose mill scale. Protective coatings on steel surfaces shall be removed by sandblasting or by a solvent that leaves no residue.

11. APPLICATION:

11.1 Paper Masking Tape: Paper masking tape shall be placed on the finish surface on one or both sides of a joint cavity to protect adjacent finish surfaces from primer or compound smears. Masking tape shall be removed within 10 minutes after joint has been filled and tooled.

11.2 Bond-Preventive Materials: Bond-preventive materials for No. 2 or 4 sealant shall be installed on the bottom of the joint cavity and other surfaces indicated to prevent the sealant from adhering to the surfaces covered by the bond-preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond-preventive materials.

11.3 Backstops: The back or bottom of joints constructed deeper than indicated shall be packed tightly with backstop material to provide a joint of the depth indicated. Where necessary to provide a backstop for oil and resin sealant, the joint shall be packed tightly with rope yarn.

11.4 Primer: Primer shall be used on concrete masonry units, wood, or other porous surfaces in accordance with instructions furnished with the sealant. Primer shall be applied to the joint surfaces to be sealed. Surfaces adjacent to joints shall not receive primer.

11.5 No. 2 or 4 Sealant: Compound shall be gun-applied with a nozzle of proper size to fit the width of joint indicated and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. Sealant shall be uniformly smooth and free of wrinkles. Joints shall be tooled slightly concave after sealant is installed. When tooling white or light-color sealant, dry or water-wet tool shall be used.

12. CLEANING: The surfaces adjoining the calked and sealed joints shall be cleaned of smears and other soiling resulting from the calking and sealing application as work progresses.

APPENDIX C:

INSTRUMENTATION SYSTEMS

Fort Benning, GA

Thermocouples were installed on the structural deck below the PUF and below the insulation on the roof areas covered by the EPDM system and the conventional BUR. Additional thermocouples and strain gauges were installed on top of the PUF coating, the EPDM sheet, and the BUR felts. The wiring for the thermocouples, strain gauges, and weather station was run into a room located below the BUR roof system. Figures C1 through C4 show the location of the thermocouples and strain gauges and Figure C5 shows the equipment layout for recording the data.

Fort Lewis, WA

Thermocouples were installed on the structural deck below the PUF and below the insulation on the roof areas covered by the EPDM system and the conventional BUR. Additional thermocouples and strain gauges were installed on top of the EPDM sheet. The wiring for the thermocouples, strain gauges, and weather station was run into a room located below the PUF roof system. Figures C6 through C12 show the location of the thermocouples and strain gauges.

Fort Knox, KY

Thermocouples were installed on the deck below the PUF, but funding considerations did not allow for the data logging equipment. Figure C13 shows the location of the thermocouples, and Figure C14 shows the proposed location of thermocouples and strain gauges on the surface of the membrane. These will be installed if the data logging equipment is obtained.

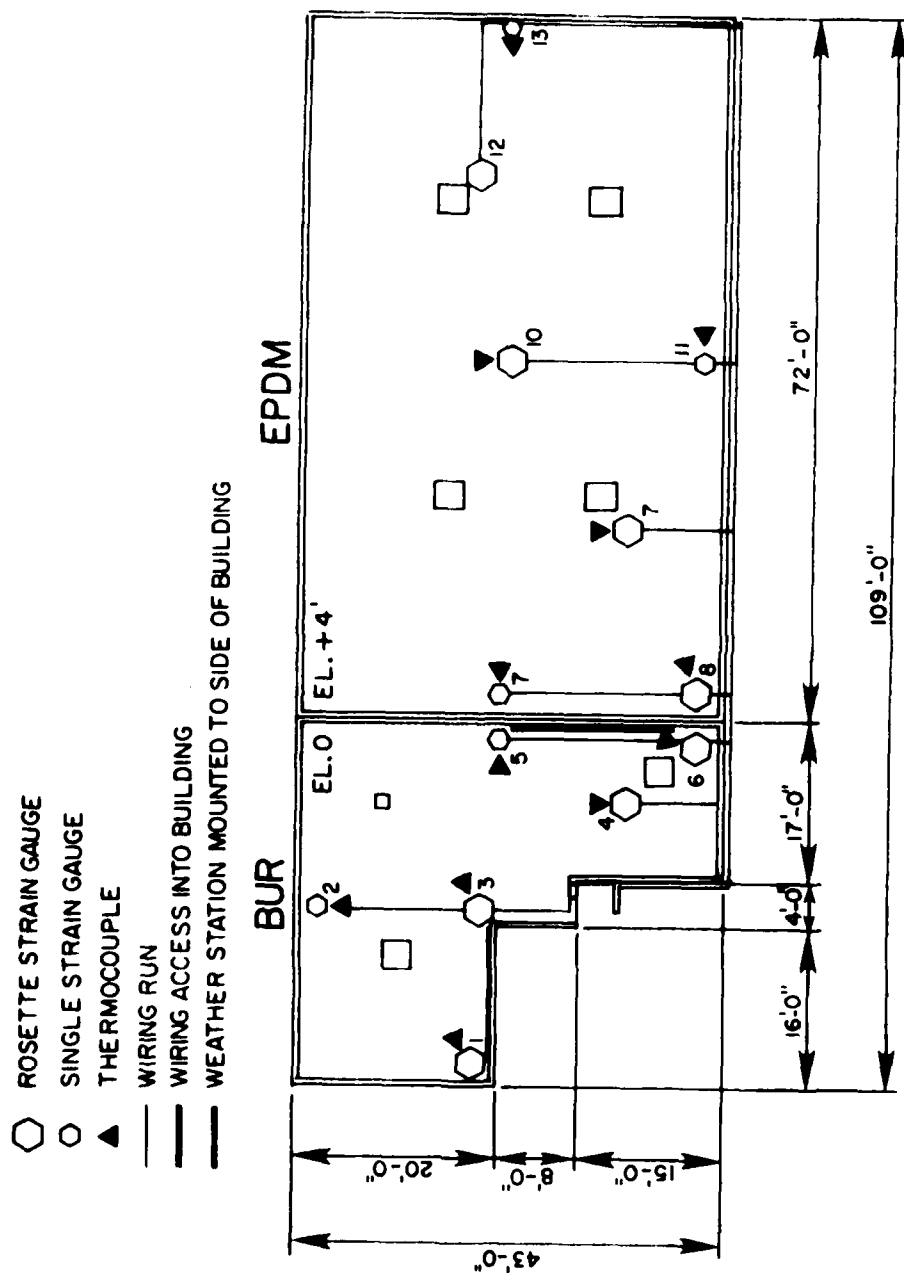


Figure C1. Thermocouples and strain gauges on top of membrane -- Building 2823, Fort Benning.

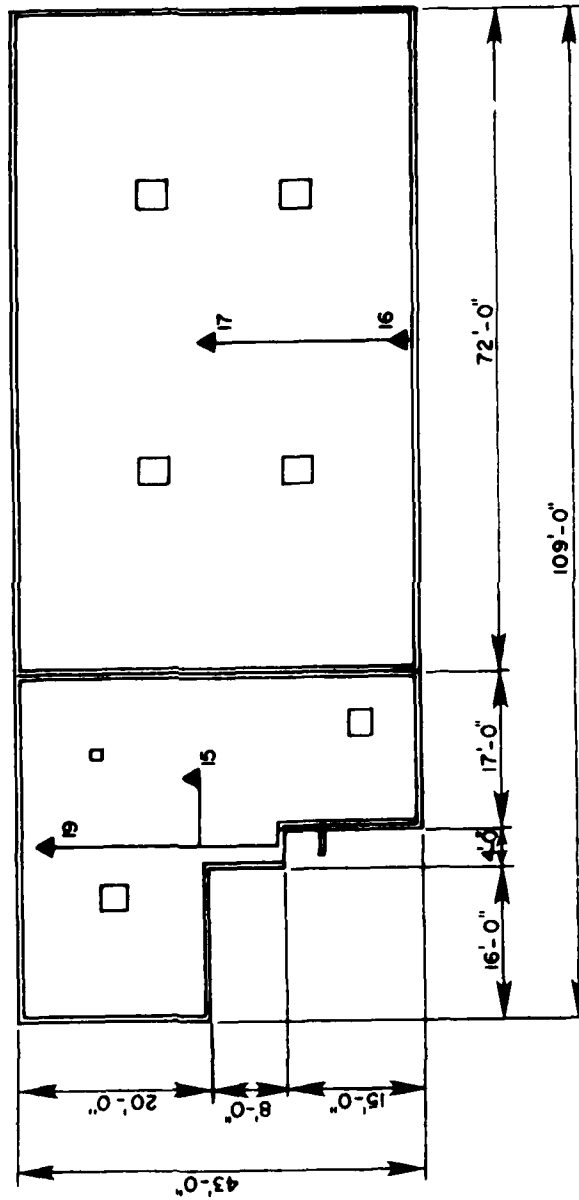


Figure C2. Thermocouples below insulation -- Building 2823, Fort Benning.

- ROSETTE STRAIN GAUGE
- SINGLE STRAIN GAUGE
- THERMOCOUPLE
- WIRING RUN
- WIRING ACCESS INTO BUILDING

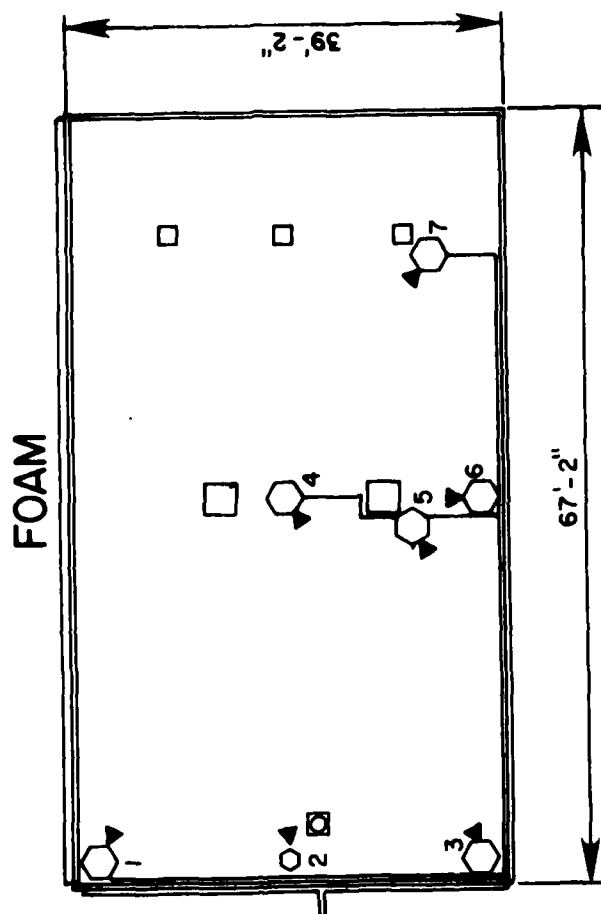


Figure C3. Thermocouples and strain gauges on top of membrane ---
Building 2806, Fort Benning.

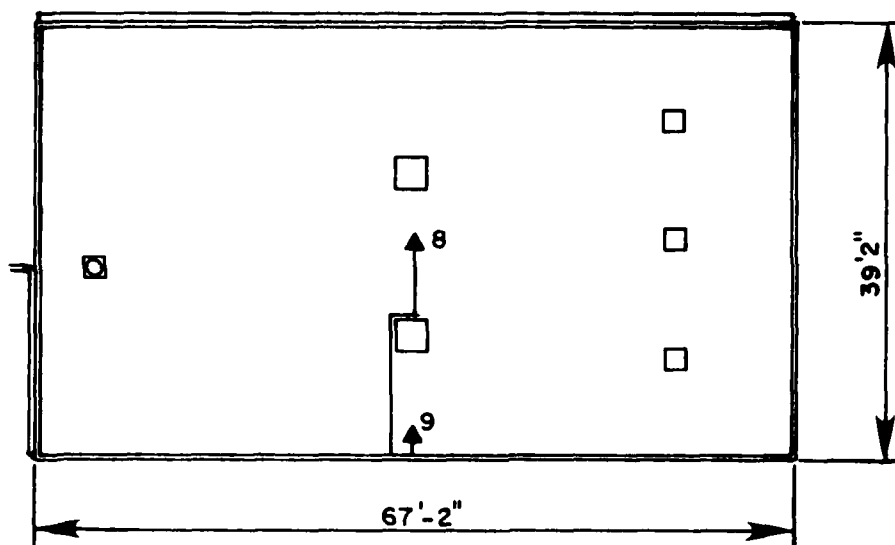


Figure C4. Thermocouples below insulation -- Building 2806, Fort Benning.

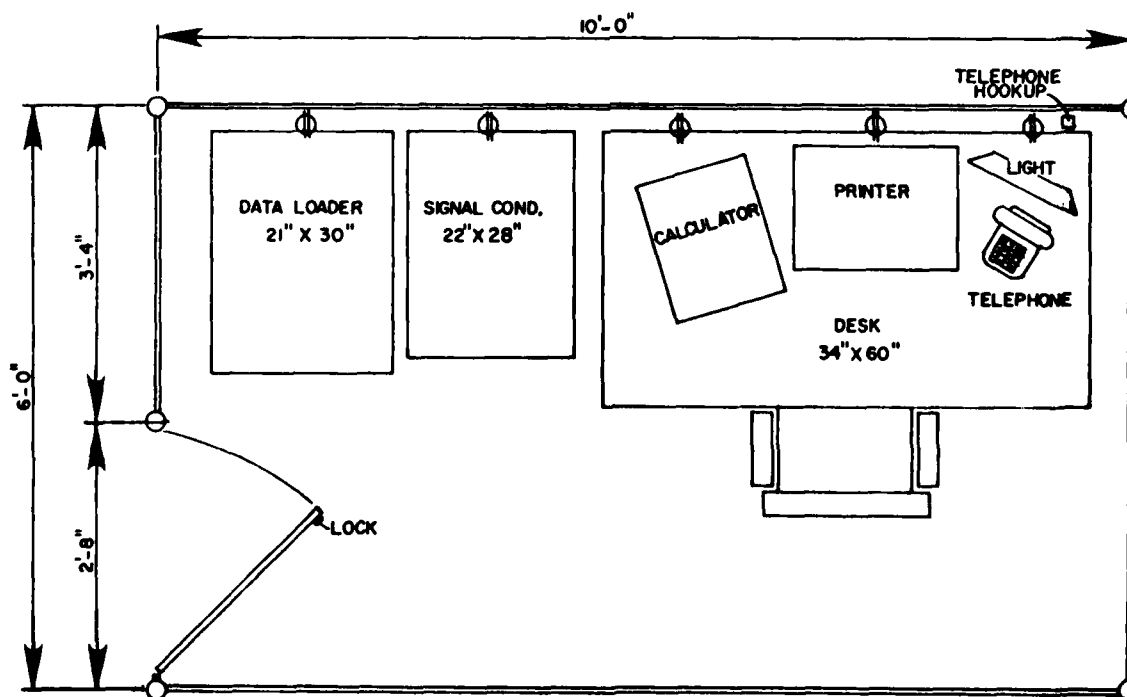


Figure C5. Data recording equipment room layout -- Fort Benning.

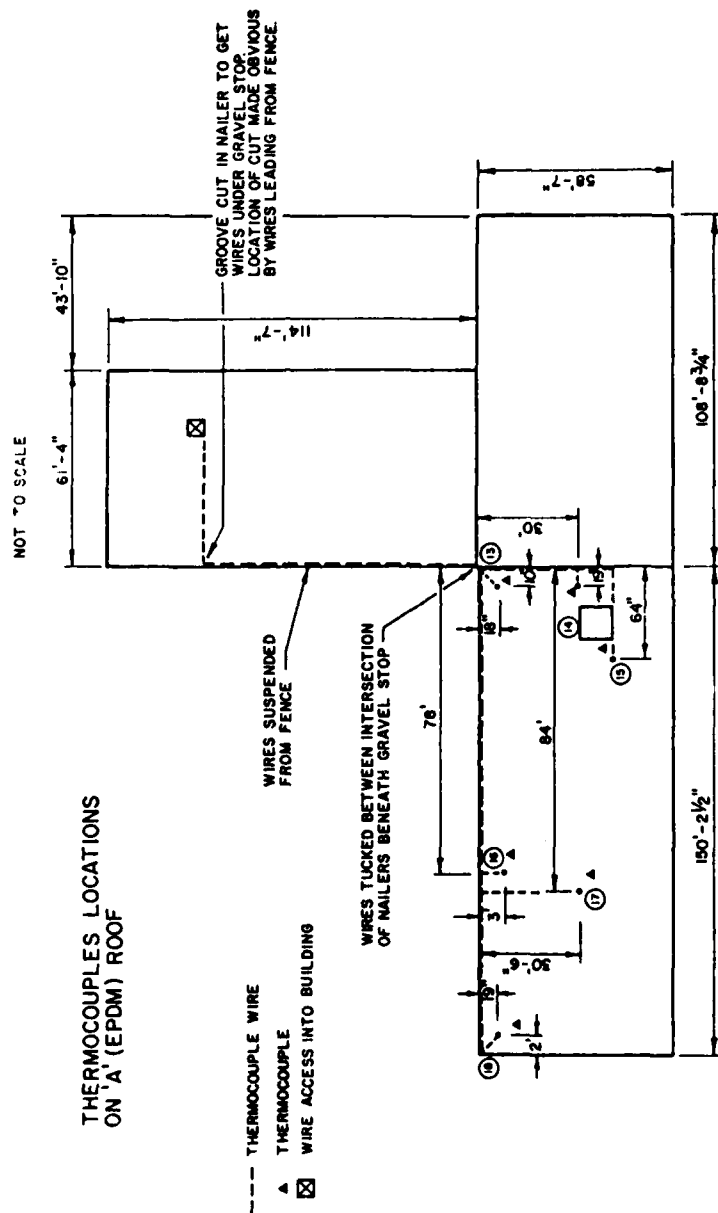


Figure C6. Thermocouples below insulation -- Building 1450,
Fort Lewis, Area A.

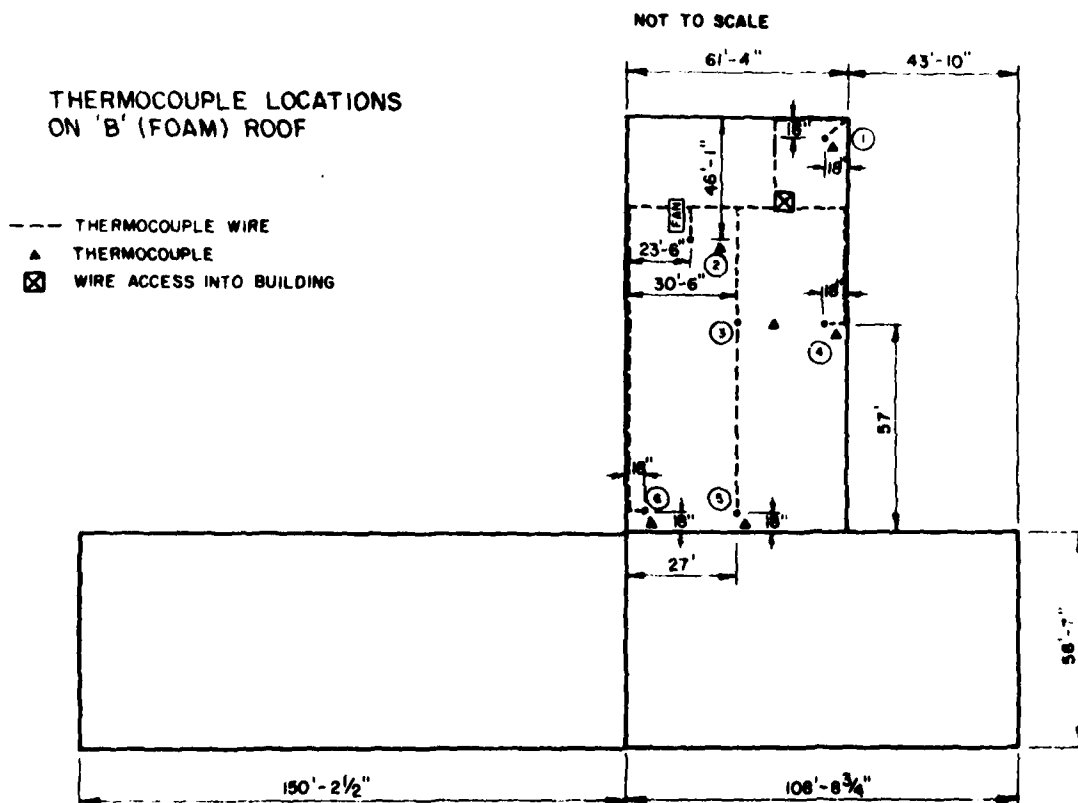
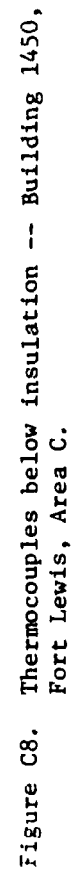


Figure C7. Thermocouples below insulation -- Building 1450, Fort Lewis, Area B.



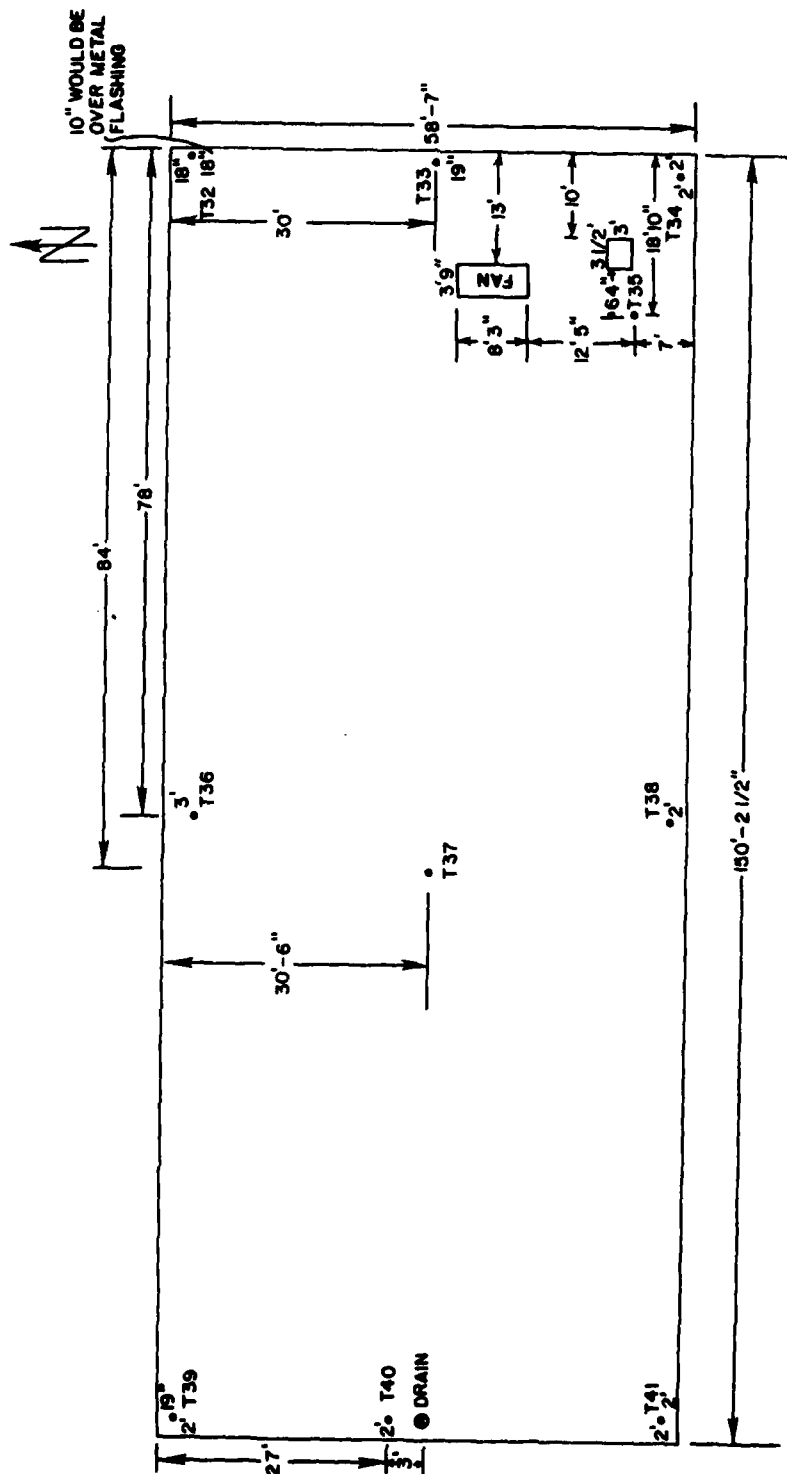


Figure C9. Thermocouples on top of membrane -- Building 1450, Fort Lewis, Area A.

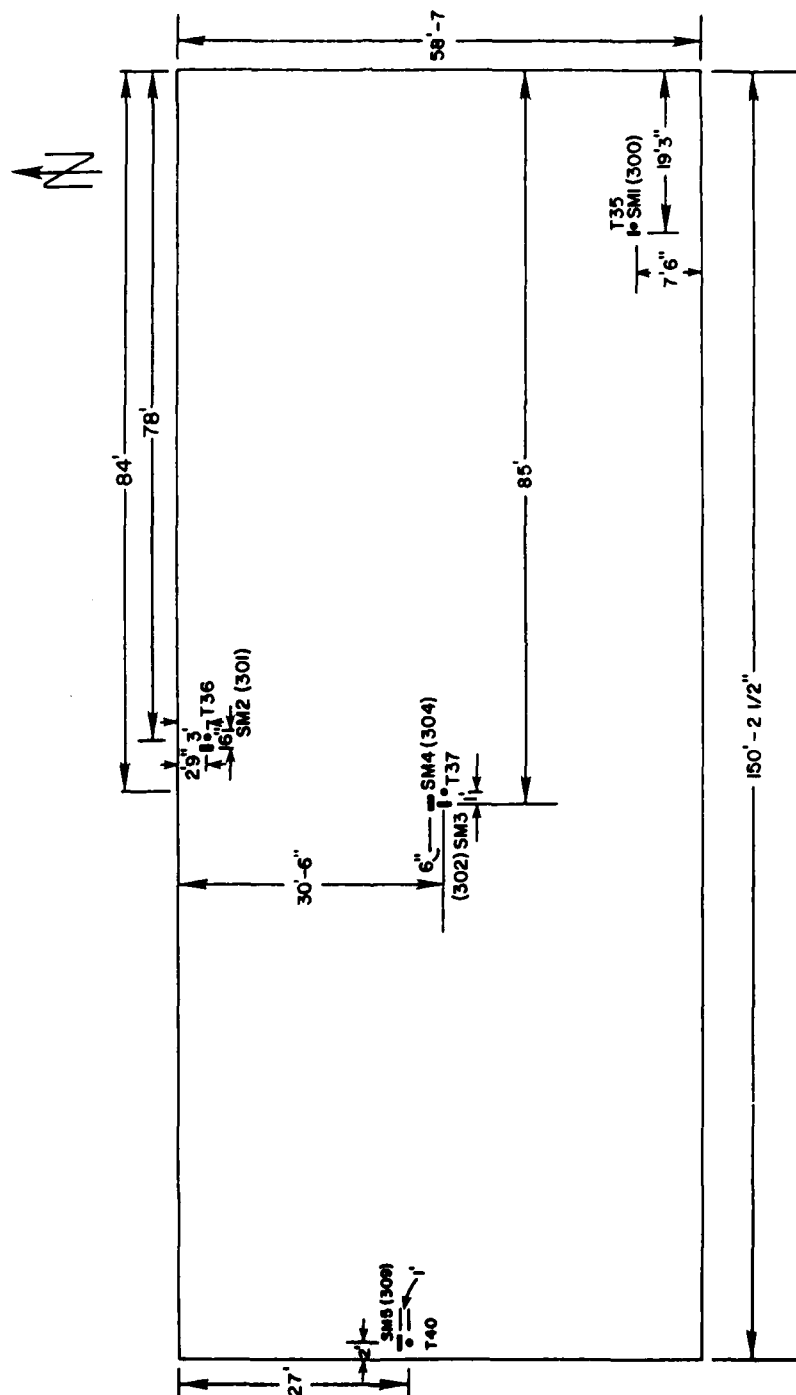


Figure C10. Strain gauges on top of membrane -- Building 1450, Fort Lewis, Area A.

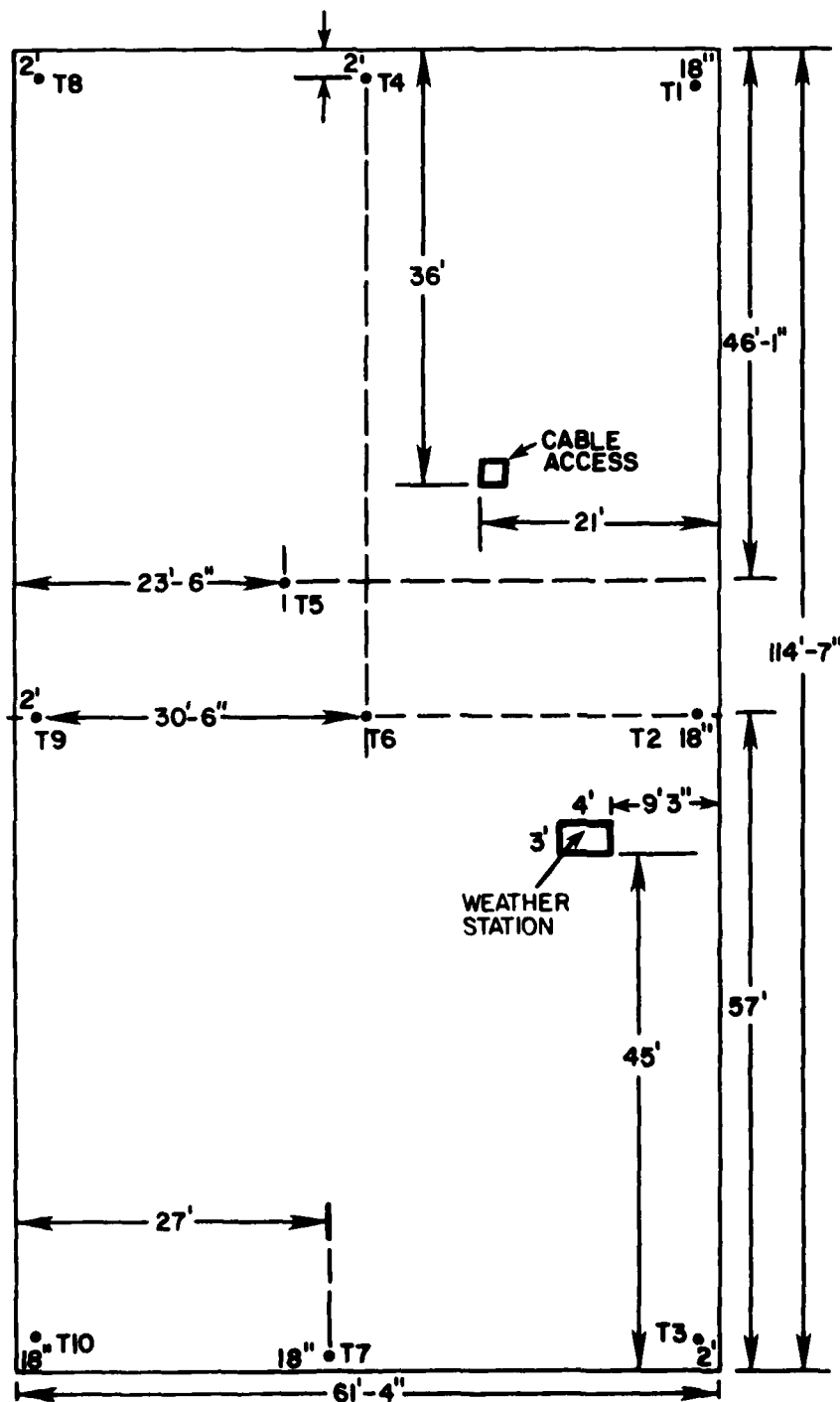


Figure C11. Thermocouples on top of membrane -- Building 1450, Fort Lewis, Area B.

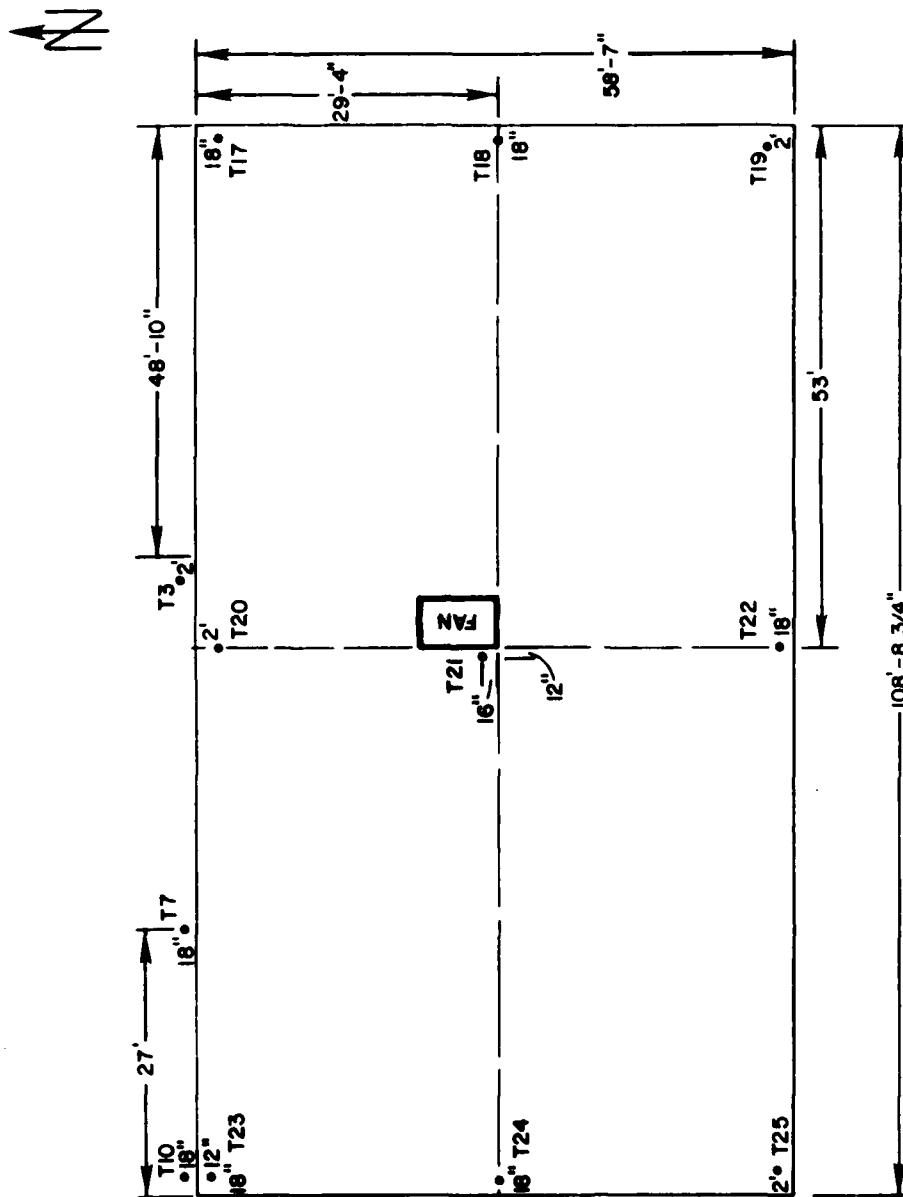


Figure C12. Thermocouples on top of membrane -- Building 1450, Fort Lewis, Area C.

- ▲ THERMOCOUPLE ON DECK
- WIRING RUN
- WIRING ACCESS INTO BUILDING

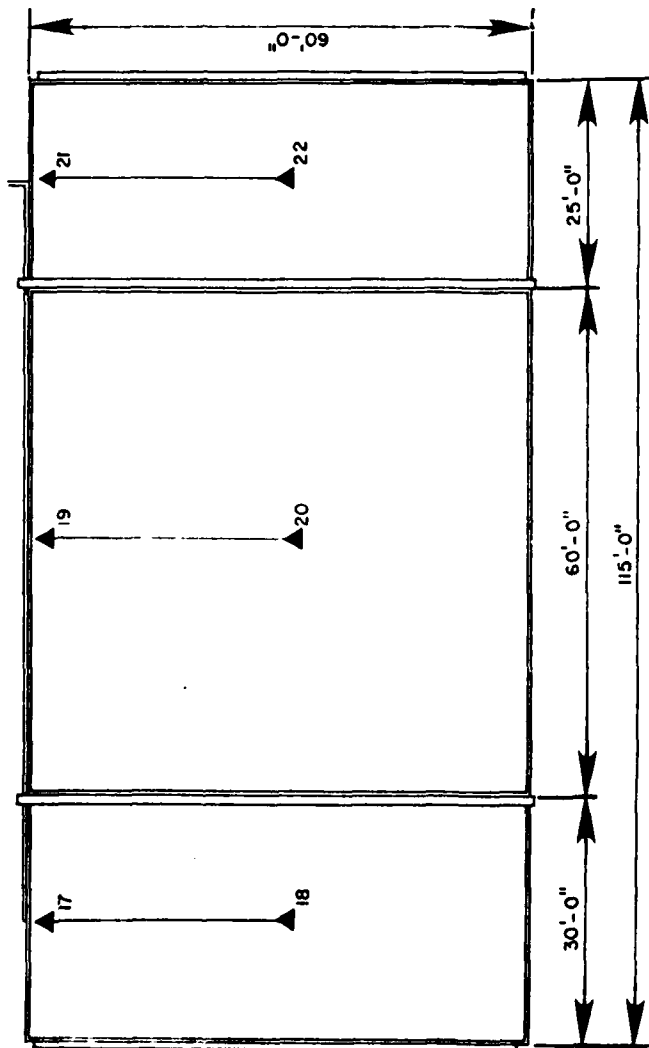


Figure C13. Thermocouples below insulation -- Building 6576, Fort Knox.

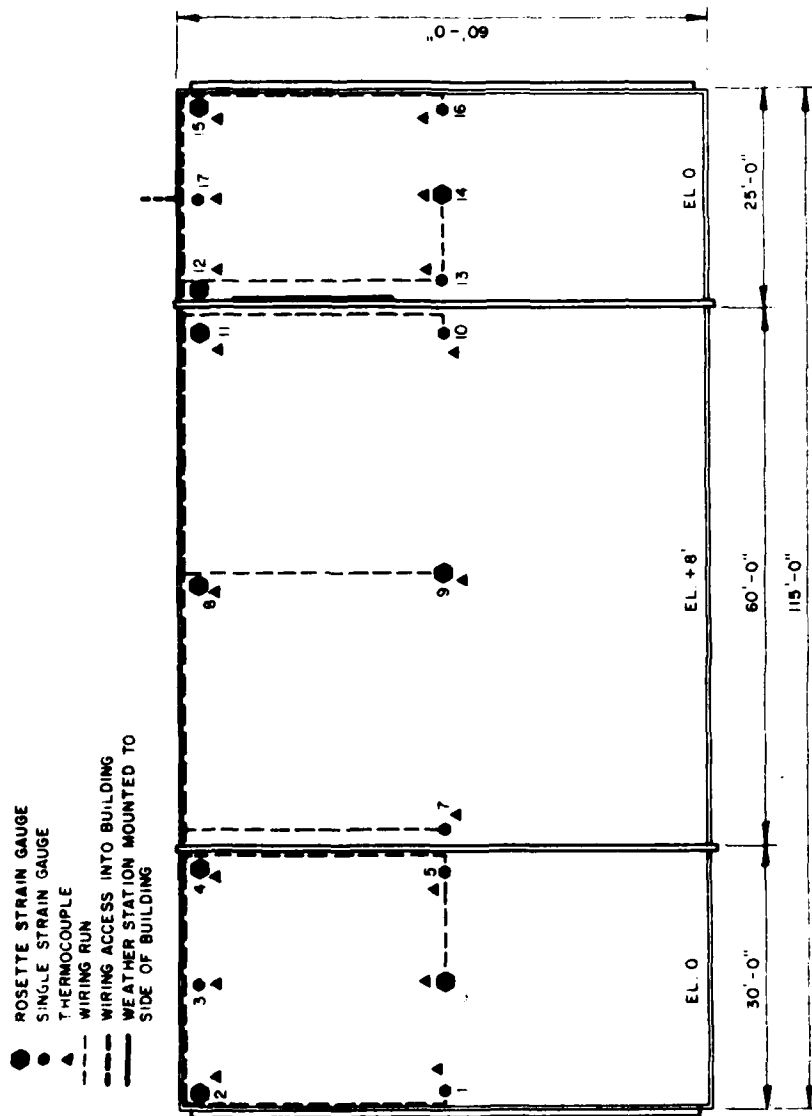


Figure C14. Thermocouples and strain gauges on top of membrane -- Building 6576, Fort Knox.

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